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ABSTRACT

This revised curriculum guide for teachers and students is designed to help prepare students for entry-level employment in the residential wiring trade. The curriculum guide contains six units that cover the following topics: (1) blueprint reading and load calculations; (2) service; (3) rough-in; (4) trim out and troubleshooting; (5) low voltage wiring; and (6) home automation. The complete teacher edition consists of introductory pages, teacher pages, and the student edition. Included in the introductory pages are information on use of the publication, a training and competency profile, a duty and task crosswalk, an instructional and task analysis, information on basic skills icons and classifications, a basic skills matrix, and a list of required tools, equipment, and materials. Teacher pages include suggested activities, answers to assignment sheets, written tests, answers to written tests, learning activities sheets, teacher supplements, and transparency masters. The student edition includes objective sheets, information sheets, student supplements, focus assignment, assignment sheets, and job sheets for each unit. (KC)

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ED 436 682

RESIDENTIAL WIRING

Third Edition

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MAVCC

Teacher Edition

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References 1999
National Electrical Code

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Residential Wiring

Third Edition

Teacher Edition

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Units of Instruction

Unit 1: Blueprint Reading and Load Calculations

Unit 2: Service

Unit 3: Rough-In

Unit 4: Trim Out and Troubleshooting

Unit 5: Low Voltage Wiring

Unit 6: Home Automation

Foreword

Residential Wiring, ©2000, is a revision of MAVCC's 1994 wiring publication of the same name. It is the second in a series of three wiring publications and picks up where Basic Wiring ends and prepares the student for entry-level employment in the residential wiring trade. A new unit on Low Voltage Wiring has been added, and the unit on Home Automation (formerly Smart House Wiring) has been updated.

Basic *Wiring*, ©1999 is the first publication in the wiring series and serves as the foundation for students enrolled in a wiring program. It is a prerequisite to either *Residential Wiring* or *Commercial and Industrial Wiring*. This series of publications should provide the flexibility that instructors need to meet the individual needs of their students and the community.

Commercial and Industrial Wiring, ©2000, is the third publication in the wiring series and includes the additional technical knowledge and applications required for job entry in the commercial and industrial wiring trade.

MAVCC's wiring series was developed with the assistance of many individuals who have expertise in various areas of the wiring trade. Some of these individuals represent professional associations and industry. Their assistance and support is greatly appreciated. It should be emphasized that the student needs to be aware of professional trade associations and take an active part in them as much as possible. The professional trade associations, as well as vocational education, are an excellent avenue for continuing education within the electrical trade.

These instructional materials are designed not only for student use but also to assist the teacher in improving instruction. Every effort has been made to make these materials basic, readable, and usable. Teachers will need to develop instructional strategies for localizing, individualizing, and supplementing these materials.

Special attention should be given to the Basic Skills Matrix in the introductory pages and to the teaching suggestions in each unit of instruction. These suggestions present academic skills being reinforced by the instructional materials and ways to increase reinforcement of workplace skills. By reinforcing basic skills, the teacher will assist students in becoming more productive workers.

As you use these instructional materials, we hope you will find they contribute to the quality of your program. If any problems occur or if you have suggestions for improvement, please call or write us.

Jim Fleihler, Chairman
Board of Directors
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Appreciation is extended to those individuals who contributed their time and talent to the development of *Residential Wiring*.

The contents of this publication were initially planned and reviewed by the following committee members:

Loren Amerine	Hoisington, Kansas
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Review and revision of this publication was completed by selected instructors in the Oklahoma Vocational-Technical Education system.

A special thank you goes to the following for providing technical information and/or granting MAVCC permission to reprint certain graphic materials that enhance this text: Alcatel Canada Wire and Cable Limited; AMP Incorporated; Harrison Electric; Delmar Publishers Inc., Intelligent Home Automation, Lutron Electronics Corporation, Inc., PHAST by PANJA, and the Custom Electronic Design and Installation Association (CEDIA).

Special thanks are also extended to Stacy Lee, Electronic Publishing Technician, for her hard work, ingenuity, accuracy, and determination in completing artwork and digitizing this edition.

Appreciation is extended to employees of the Graphics Division of the Oklahoma Department of Vocational-Technical Education for artwork and printing of this text.

Thanks are also extended to Glenn Fleming, Project Coordinator, and to Jane Huston, MAVCC Curriculum Coordinator.

Use of This Publication

Residential Wiring is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the residential wiring advisory committee, comprised of business/industry representatives and teachers. Competencies align with the Oklahoma Electrical Trades duty/task list, Residential Electricians Assistant, developed by the Oklahoma Department of Vocational and Technical Education.

Teacher Edition

The complete teacher edition consists of introductory pages, teacher pages, and the student edition. Materials are loose-leaf and three-hole punched and are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages are represented as T 3–17.

MAVCC—*Residential Wiring* T 3–17

Page 1 of Unit 5 in the teacher pages are represented as T 5–1.

MAVCC—*Residential Wiring* T 5–1

Pages in the student edition are numbered beginning with the unit number, followed by the page number.

Example:

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

MAVCC—*Residential Wiring* Page 5–7

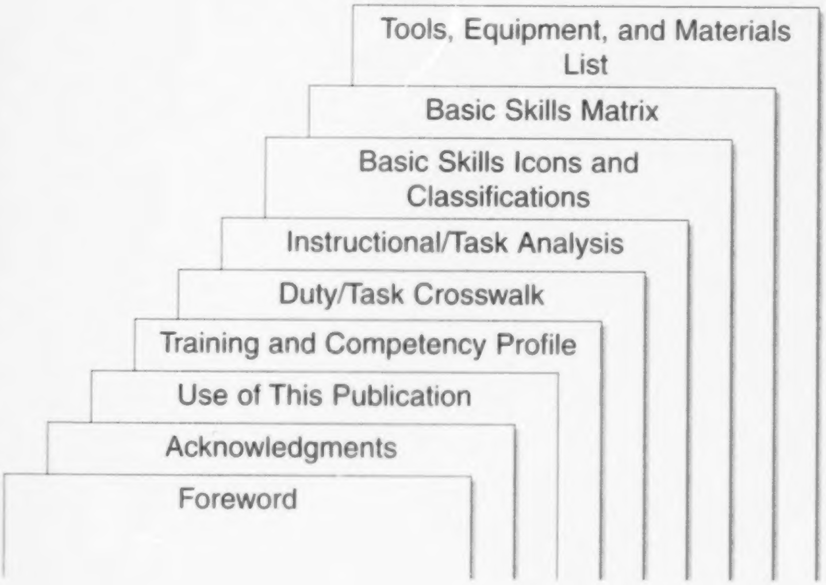
Use of This Publication

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages


Tools, Equipment, and Materials List
Basic Skills Matrix
Basic Skills Icons and Classifications
Instructional/Task Analysis
Duty/Task Crosswalk
Training and Competency Profile
Use of This Publication
Acknowledgments
Foreword

Use of This Publication

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

☐ **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

☐ **Duty/Task Crosswalk.** This document identifies the state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective.

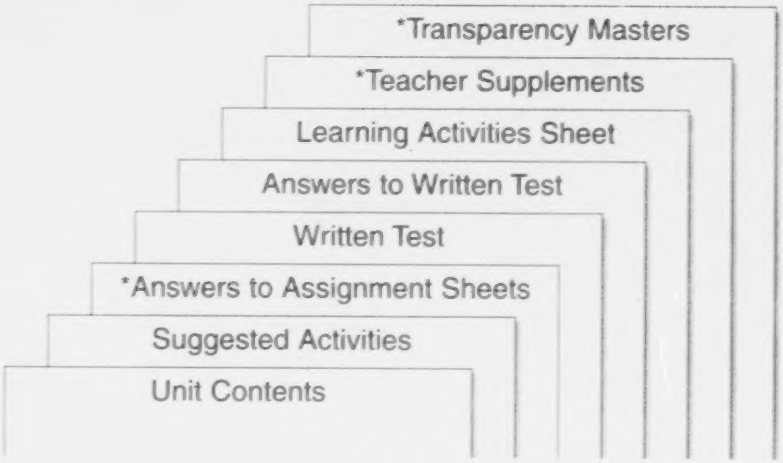
☐ **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

☐ **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each focus assignment, assignment sheet, and job sheet.

☐ **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

☐ **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Teacher Pages


*Transparency Masters
*Teacher Supplements
Learning Activities Sheet
Answers to Written Test
Written Test
*Answers to Assignment Sheets
Suggested Activities
Unit Contents

*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

- ☐ **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

  Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

- ☐ **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

- ☐ **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

☐ **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

☐ **Learning Activities Sheet.** This component provides a model for teachers to use in implementing a self-paced or individualized program, and guides the student through the required components in the student edition (objective sheet, information sheet, student supplements, assignment sheets, and job sheets). The teacher should modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student. Final copies should be distributed for student use.

The following icons will be used on the learning activities sheet to denote steps that require additional resources:

📖 Read a book, magazine, journal article, or objectives

💻 Use a CBT program or other software application

WWW Access a site on the World Wide Web

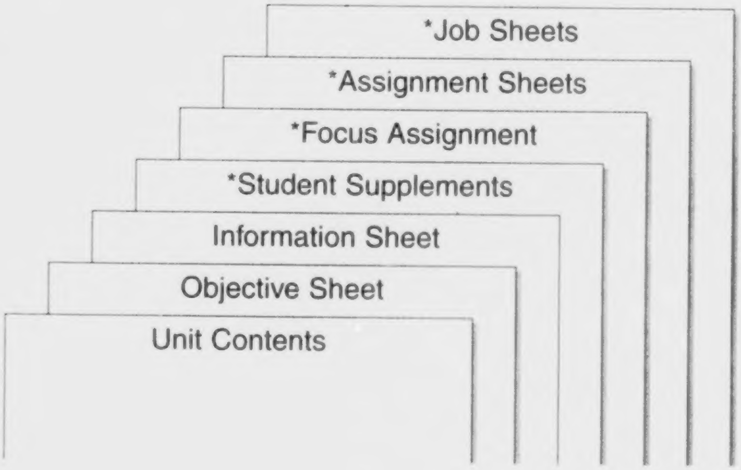
🖥 Look at PowerPoint® or other computer presentation

📼 Watch a videotape

☐ **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

☐ **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

☐ **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

☐ **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

☐ **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

☐ **Focus Assignment.** This activity provides students with an opportunity to explore topics presented in a specific unit of instruction, and gives them an opportunity to practice their reading, language skills including writing and speaking, and critical-thinking skills.

☐ **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

☐ **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

Use of This Publication

The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or E-mail us at mavcc@okvotech.org.

Training and Competency Profile

Student Information

Program ______________________ Instructor ______________________

Name ______________________ Soc. Sec. No. ______________________

Address ______________________ Phone ______________________

Grade ____________ School ______________________

Allergies/Disabilities that might require special accommodation for training (please specify)

____

In case of emergency, contact ______________________ Phone ______________________

Record of Enrollment

Date of Enrollment ____-____-____ Total Class Hours________ Total Hours Absent________

Date of Withdrawal ____-____-____ Total On-the-Job Training Hours________ Total Hours Tardy________

Date of Completion ____-____-____ Total Lab Hours________

On-the-Job Training/Work Experience

Place of Employment ______________________ Address ______________________

Supervisor's Name ______________________ Phone ______________________

Duration of Employment ______________________ Job Title ______________________

Job Responsibilities ____

Place of Employment ______________________ Address ______________________

Supervisor's Name ______________________ Phone ______________________

Duration of Employment ______________________ Job Title ______________________

Job Responsibilities ____

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using one of the rating scales below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scorelines are provided for optional teacher use. They may not be applicable in all cases.

Sample A

4 **Skilled**—Can perform job with no additional training.
3 **Moderately Skilled**—Has performed job during training program; limited additional training may be required.
2 **Limited Skill**—Has performed job during training program; additional training is required to develop skill.
1 **Unskilled**—Is familiar with process, but is unable to perform job.
0 **No Exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

Unit 1: Blueprint Reading and Load Calculations

______ 1. Draw receptacle and lighting outlets on a floor plan.
______ 2. Determine general lighting loads.
______ 3. Determine small appliance and laundry loads.
______ 4. Determine total connected load plus total demand load of a dwelling.
______ 5. Locate required receptacle and lighting outlets on a house plan.
______ 6. ______________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 2: Service

______ 1. Calculate service size and minimum number of circuits.
______ 2. Install an overhead raceway with service entrance conductors to a meter base.
______ 3. Connect meter base assembly to load center or panel.
______ 4. Install an underground service (lateral) raceway with conductors to a meter base.
______ 5. Braid the ground conductor of a service entrance cable.
______ 6. ______________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 3: Rough-In

______ 1. List systems that must be installed in a residence prior to installing the wall finish.
______ 2. Locate receptacle switch, and lighting outlets along a floor line and the ceiling on a blueprint.
______ 3. Locate receptacle outlets along kitchen cabinets.
______ 4. Locate receptacle outlets in a bathroom.
______ 5. ______________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 4: Trim Out and Troubleshooting

______ 1. List and price lighting fixtures.
______ 2. Troubleshoot electrical problems.
______ 3. Wire a receptacle fed from a lighting outlet through a single pole switch.
______ 4. Wire a switch controlled split-wired receptacle.
______ 5. Wire a receptacle fed from a lighting outlet through a three-way switch.
______ 6. Wire a four-way switching situation with the supply entering the lighting outlet box.
______ 7. Mount a fan box according to manufacturer's recommendations.
______ 8. Install a range or dryer receptacle.
______ 9. Connect a supply cord to a free standing range or dryer.
______ 10. Install a fixed appliance equipped with a pigtail to a branch circuit.
______ 11. Install a multi-circuit split-wired duplex grounding type receptacle.
______ 12. Install a fusible safety switch for an air-conditioning condenser.
______ 13. ______________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 5: Low Voltage Wiring

______ 1. List licensing requirements for low voltage wiring systems.
______ 2. List uses of low voltage cable.
______ 3. Draw a wiring diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors.
______ 4. Wire a two-button chime circuit.
______ 5. Wire two interconnecting telephone wall jacks.
______ 6. Wire two interconnecting smoke detectors.
______ 7. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Unit 6: Home Automation

______ 1. Use Article 780 of the *National Electrical Code* to answer questions related to home automation wiring.
______ 2.
______ 3. ______________________________

Written Test Scores
Pretest Score ________%
Posttest Score ________%

Duty/Task Crosswalk

This duty/task crosswalk is based on the Oklahoma Duty/Task List for the Electrical Trades, Residential Electrical Assistant, and can be used as a cross-reference in other states.

Abbreviations:

FA—Focus Assignment
AS—Assignment Sheet
JS—Job Sheet

Skill Code	Skill Description	Unit #	Specific Reference
E.02	Inventory equipment and supplies	1-5	
E.12	Draw an "as built" electrical plan	1/4	AS 1&5/AS 2
G.02	Analyze and apply principles of transformers to AC Circuits – low voltage	5	JS 1
I.02	Calculate the grounding electrode system and bonding requirements	2	JS 1
I.04	Calculate the load in volt-amps and load current in amps	1	AS 2-4
I.05	Calculate service size	2	JS 1
I.06	Determine the number of convenience and appliance outlets per circuit	1	AS 3
I.09	Calculate conductors	2	AS 1
I.11	Calculate over-current protection	2	JS 1
J.01	Ground service equipment	2	
J.02	Install main service panels	2	JS 2
J.09	Install underground service	2	JS 3
J.10	Install metering equipment	2	JS 1&2
K.02	Install recessed fixture housings in ceilings	4	JS 5
K.03	Install bar-hanger mounted box	4	JS 1&3-5
K.04	Install flush mount junction box	4	JS 9
K.05	Install flush mount switch and outlet box in – dry wall	4	JS 1-4&6
K.06	Install gangable boxes	4	JS 5
K.07	Install octagon outlet box	4	JS 1-3
K.08	Install surface mount junction box	4	JS 8

Duty/Task Crosswalk

L.01	Layout electrical systems		
	– use material and devices labeled and listed for the purpose	4	JS 1-6&8, 9
	– follow all grounding and bounding requirements	4	JS 1-9
L.02	Rough-in feeders and circuits using a cable system		
	– new construction	2	JS 1-6&8-10
L.03	Rough-in new circuits and other raceways in conduits		
	– new construction	2	JS 1-3
L.04	Rough-in cables or conduits for branch circuits	4	JS 3, 4&8
L.05	Connect circuits to circuit breaker panels	2/4	JS 2&3/JS 1-6&9
L.06	Rough-in circuits to outlet boxes	4	JS 1-6&8
L.08	Rough-in a circuit for an outlet controlled with		
	– three-way switches	4	JS 3
	– feed to the device outlet box	4	JS 2&5
	– feed to the device	4	JS 4&9
L.09	Rough-in low-voltage circuits		
	– door chime system	5	JS 1
L.10	Rough-in cables for general purpose branch circuits		
	– single pole switch	4	JS 1, 2, 5&10
	– three-way switch	4	JS 3
	– receptacle outlet	4	JS 1, 2, 5, 6, 8&9
	– lighting outlet	4	JS 3
L.11	Make splices		
	– wire nuts	4	JS 1-6, 9&10
L.13	Make terminations	4	JS 1-6&9
L.14	Rough-in branch circuit wires to panels	4	JS 1-5&9
L.15	Install panels and subpanels	2	JS 2
L.20	Install conduits, cables, raceways, and equipment		
	– indoor	2	JS 1
	– underground	2	JS 3
	– rigid	4	JS 10
	– plastic	2	JS 3
	– thin wall (EMT)	4	JS 10
	– multi-conductor	2	JS 1&3
	– wet locations	2	JS 1
L.21	Install receptacle circuits		
	– single phase	4	JS 1-6, 8&9
M.11	Install/connect for air conditioning systems	4	JS 10
N.01	Install/connect all lighting fixtures and circuits	4	JS 1-4
N.02	Install/connect fans	4	JS 5
N.07	Install/connect receptacles	4	JS 1-6&8
N.08	Install/connect switches	4	JS 1-5&10

N.10	Install/connect appliances	4	JS 6-8
N.14	Install/connect low-voltage systems	5	JS 1-3
N.20	Install smoke and CO detectors	5	JS 3
O.03	Troubleshoot/repair/replace lighting fixtures	4	AS 1
O.06	Troubleshoot/repair/replace service entrance equipment	4	AS 1
P.06	Install and connect system grounds	4	JS 1-9
P.07	Install raceway systems and conductors	2	JS 1
T.01	Troubleshoot/install/connect/replace power and control transformers	5	JS 1
T.02	Troubleshoot/install/connect/replace door chime systems	5	JS 1
T.04	Troubleshoot/install/connect/replace telephone systems	5	JS 2
T.05	Troubleshoot/install/connect/replace emergency warning systems – fire	5	AS 2, JS 3
U.02	Demonstrate appropriate interpersonal skills	All	
U.03	Maintain self-esteem in self and others	All	
U.04	Recognize the importance of team work and participate as a team member	All	
U.05	Maintain professional respect for co-workers and supervisor	All	
U.06	Demonstrate professionalism	All	
U.07	Practice critical thinking skills to workplace situations – decision making	All 3/4	FA, AS 1-3/AS 1
U.08	Maintain satisfactory attendance	All	
U.10	Function within the organizational structure	All	
U.11	Cooperate with co-workers in the completion of assignments	All	
U.12	Practice self-management (time management) techniques	All	
U.13	Practice deductive and inductive reasoning skills	All	
U.15	Employ listening skills	All	
U.16	Compose written communication legibly using correct grammar, spelling, and format – use reference materials	3/4	FA/FA
U.17	Demonstrate ability to interpret and follow written directions and information	All	
U.18	Demonstrate ability to interpret and follow oral directions	All	
U.19	Use job-related terminology, symbols, and abbreviations	All	
U.21	Use effective communication techniques	All	

Duty/Task Crosswalk

U.22	Use verbal and non-verbal communication techniques	All	
U.23	Apply behavior management techniques to workplace	All	
U.25	Respond to compliments, complaints, conflicts, and criticism appropriately	All	
U.28	Demonstrate negotiation skills – solve everyday human relations problems	All	
U.29	Demonstrate leadership skills – employ leadership skills	All	

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 1: Blueprint Reading and Load Calculations

1. Terms and definitions
2. Blueprint symbols
3. Electrical symbols
4. Types of lines
5. Information commonly found in blueprint specifications
6. Minimum requirements for residential outlets
7. Calculating circuit loads and voltage drop
8. Draw receptacle and lighting outlets on a floor plan
9. Determine general lighting loads
10. Determine small appliance and laundry loads
11. Determine total connected load plus total demand load of a dwelling
12. Locate required receptacle and lighting outlets on a house plan

Unit 2: Service

1. Terms and definitions
2. Clearances for service drop conductors
3. Service disconnects
4. Facts that should be known before service installation is started
5. Parts of a service entrance
6. Types of grounding electrodes
7. Grounding electrode conductor installations and sizes
8. Short circuit protection at service equipment
9. Surge protection
10. Calculate service size and minimum number of circuits
11. Install an overhead raceway with service entrance conductors to a meter base
12. Connect meter base assembly to load center or panel
13. Install an underground service (lateral) raceway with conductors to a meter base
14. Braid the ground conductor of a service entrance cable

Unit 3: Rough-In

1. Terms and definitions
2. Locations where at least one receptacle outlet is required
3. Planning techniques when placing boxes on plans
4. Accepted heights for boxes in various locations

Instructional/Task Analysis

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 3: Rough-In (continued)

5. Procedure for installing boxes in exterior walls
6. Box extensions for noncombustible and combustible wall surfaces
7. Common methods of finding room centers
8. Required outlets
9. Locations requiring GFCI protection
10. Rules for electrical installations

11. List systems that must be installed in a residence prior to installing the finish.
12. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a blueprint
13. Locate receptacle outlets along kitchen cabinets
14. Locate receptacle outlets in a bathroom

Unit 4: Trim Out and Troubleshooting

1. Terms and definitions
2. Common residential receptacle types and cover plates
3. Common residential switch types and cover plates
4. Common residential fixture locations
5. Appliance classifications
6. Requirements for appliance disconnect means
7. Grounding requirements for appliances
8. Parts of a duplex grounding type receptacle
9. Parts of an equipment grounding system
10. Steps for panel trim out
11. Troubleshooting procedures

12. List and price lighting fixtures
13. Troubleshoot electrical problems
14. Wire a receptacle fed from a lighting outlet through a single pole switch
15. Wire a switch controlled split-wired receptacle
16. Wire a receptacle fed from a lighting outlet through a three-way switch
17. Wire a four-way switching situation with the supply entering the lighting outlet box
18. Mount a fan box according to manufacturer's recommendations
19. Install a range or dryer receptacle
20. Connect a supply cord to a free standing range or dryer
21. Install a fixed appliance equipped with a pigtail to a branch circuit
22. Install a multi-circuit split-wired duplex grounding type receptacle
23. Install a fusible safety switch for an air-conditioning condenser

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 5: Low Voltage Wiring

Related Information: What the Student Should Know

1. Terms and definitions
2. Requirements of low voltage lighting systems
3. Parts of a low voltage lighting system
4. Process that takes place during a low voltage lighting circuit off/on cycle
5. Components and operation of a door bell chime circuit
6. Manual fan switching circuit
7. Thermostat system switch in the cool position and the fan switch on auto
8. Thermostat system switch in the heat position and the fan switch on auto
9. Anticipator circuits on low voltage thermostats
10. Communication circuits and their characteristics
11. Smoke and fire alarm systems
12. Garage door opener operation

Application: What the Student Should Be Able to Do

13. List licensing requirements for low voltage wiring systems
14. List uses of low voltage cable
15. Draw a wiring diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors
16. Wire a two-button chime circuit
17. Wire two interconnecting telephone wall jacks
18. Wire two interconnecting smoke detectors

Unit 6: Home Automation

Related Information: What the Student Should Know

1. Terms and definitions
2. Definition of home automation
3. Operation of an automated home
4. Components of a home automation system
5. Types of cable used in home automation
6. Types of controllers
7. Special tools used in home automation

Application: What the Student Should Be Able to Do

8. Use Article 780 of the *National Electrical Code* to answer questions related to home automation

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each focus assignment, assignment sheet, and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000,* a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want,* a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development

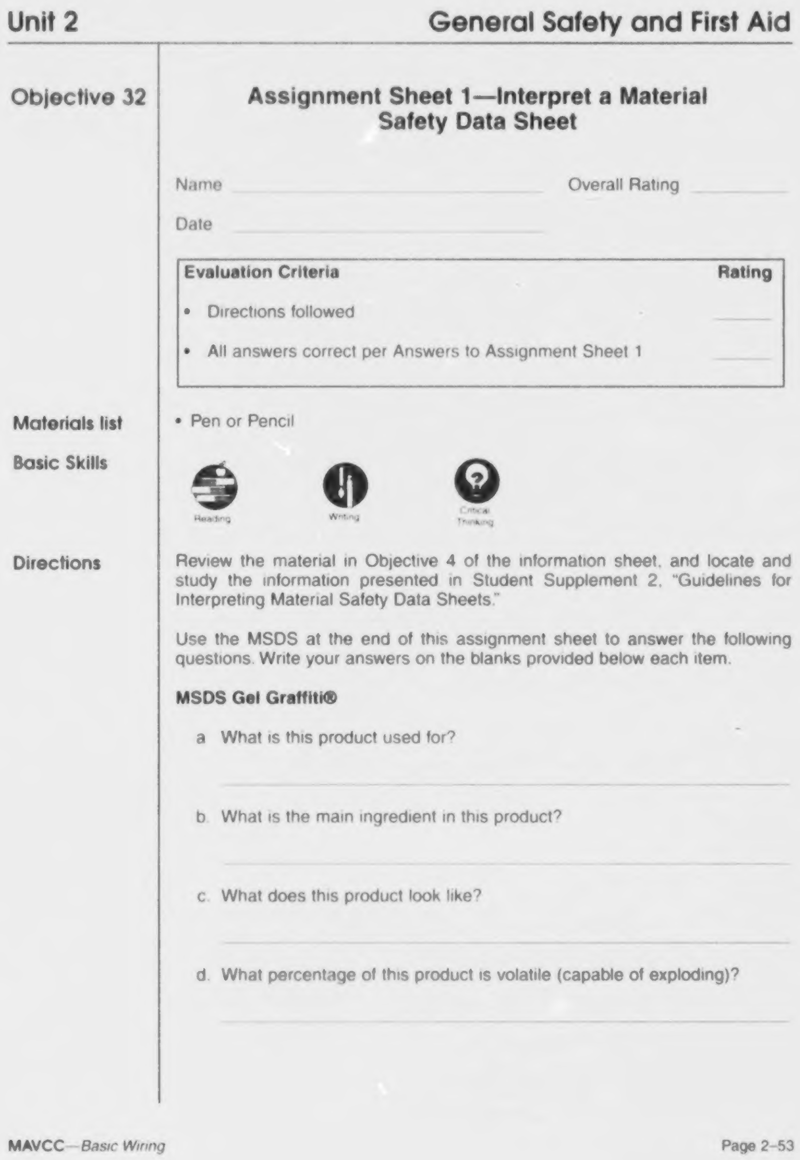
Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Basic Skills Icons and Classifications

When an activity involving one of these basic skills is identified, the corresponding icon is placed in the left-hand margin of the focus assignment, assignment sheet, and job sheet. Skills training is further defined by classifying specific skills that are required. (See skills list that may be found on each basic skills matrix.)

Example:



Unit 2 **General Safety and First Aid**

Objective 32

Assignment Sheet 1—Interpret a Material Safety Data Sheet

Name ____________ Overall Rating ______

Date ____________

Evaluation Criteria	**Rating**
• Directions followed	______
• All answers correct per Answers to Assignment Sheet 1	______

Materials list • Pen or Pencil

Basic Skills

Reading Writing Critical Thinking

Directions Review the material in Objective 4 of the information sheet, and locate and study the information presented in Student Supplement 2, "Guidelines for Interpreting Material Safety Data Sheets."

Use the MSDS at the end of this assignment sheet to answer the following questions. Write your answers on the blanks provided below each item.

MSDS Gel Graffiti®

a. What is this product used for?

____

b. What is the main ingredient in this product?

____

c. What does this product look like?

____

d. What percentage of this product is volatile (capable of exploding)?

____

MAVCC—*Basic Wiring* Page 2-53

BASIC SKILLS MATRIX

Reading Skills

UNITS OF INSTRUCTION	Reading Comprehension									Research/Reference								Functional Reading					
	Gain factual information	Distinguish fact, opinion and inference	Recognize stereotyping and bias	Recognize propaganda	Analyze cause and effect	Draw conclusions	Make generalizations	React to written material	Apply word analysis techniques	Select useful resources	Locate resources	Find materials in library	Use standard references	Use in-book reference tools	Use audiovisual media	Use computer data base	Use magazines and newspapers	Interpret forms and records	Follow written instructions	Interpret graphics and symbols	Use content area vocabulary	Interpret abbreviations/acronyms	Read aloud
Unit 1.																			X				
Unit 2.																			X				
Unit 3.						X													X				
Unit 4.														X					X				
Unit 5.								X											X				
Unit 6.											X		X						X				

BASIC SKILLS MATRIX

Writing Skills

UNITS OF INSTRUCTION	Language		Composition								Research					Functional Writing						
	Use standard grammar, spelling, and capitalization	State ideas clearly	Use complete sentences	Develop preliminary outline	Use topic sentences	Use introductory/closing paragraphs	Compose reports	Compose essays	Proofread and edit	Construct graphics and symbols	Take notes	Use note cards	Create bibliography	Use footnotes	Outline material	Complete forms and records	Write instructions	Write letters	Write job applications	Write resumes	Use word processing	Use computer graphics
Unit 1.										X												
Unit 2.																						
Unit 3.		X								X												
Unit 4.		X																				
Unit 5.	X									X												
Unit 6.	X																					

BASIC SKILLS MATRIX

Math Skills

UNITS OF INSTRUCTION	Operation and Calculation														Math Application										
	Round off numbers	Estimate answers	Use scientific notations	Use exponential notations	Calculate with whole numbers	Calculate with fractions	Calculate with decimals	Convert whole numbers to fractions	Convert whole numbers to decimals	Solve numerical expressions	Solve formulae and equations	Obtain squares and square roots	Converts units of measure	Perform metric calculations	Solve word problems	Select/apply mathematical formula	Select/apply mathematical procedure	Use English and metric measures	Solve time/rate/distance problems	Solve ratio/proportion problems	Solve percent problems	Apply techniques of scaling	Apply algebra principles	Apply geometry principles	Apply trigonometry principles
Unit 1.					X												X				X				
Unit 2.					X												X				X				
Unit 3.																									
Unit 4.																									
Unit 5.																									
Unit 6.																									

BASIC SKILLS MATRIX

Math Skills (continued)

UNITS OF INSTRUCTION	Data Analysis and Display										Functional Math													
	Interpret charts and tables	Interpret graphs	Collect/record data	Apply sampling techniques	Apply principles of probability	Construct charts and tables	Construct graphs	Calculate statistics	Interpret statistics	Interpret plans/blueprints	Make measurements	Perform banking transactions	Make change	Solve practical problems	Calculate gross earnings	Solve income/expense problems	Prepare a budget	Calculate interest	Solve interest problems	Calculate sales tax	Determine income tax	Use calculator for computation	Use computer for computation	Use computer spreadsheets
Unit 1.											X			X										
Unit 2.																								
Unit 3.																								
Unit 4.																								
Unit 5.																								
Unit 6.																								

BASIC SKILLS MATRIX

Science Skills

	General Science									Life Science						
UNITS OF INSTRUCTION	Apply computing skills	Apply scientific method of inquiry	Conduct experiments/Practicals	Investigate science ethics	Investigate science history	Investigate/apply economics in technology	Use scientific instruments	Investigate/apply technology	Collect specimens	Identify/classify living organisms	Investigate biological history of the earth	Investigate food chains, webs, pyramids	Investigate/apply principles of human development	Investigate/apply principles of genetics/heredity	Investigate/apply principles of anatomy/physiology	Investigate health issues
Unit 1.																
Unit 2.																
Unit 3.																
Unit 4.																
Unit 5.																
Unit 6.																

BASIC SKILLS MATRIX

Science Skills (continued)

	Physical Science					Earth Science										
UNITS OF INSTRUCTION	Analyze/classify matter	Investigate forms/changes of matter	Investigate forms/changes of energy	Investigate/apply chemical properties	Investigate/apply physical laws	Investigate physical characteristics of the earth	Investigate geological history of the earth	Investigate physical forces acting on the earth	Solve problems of longitude, latitude, and time zones	Investigate conservation of physical resources	Investigate conservation of living resources	Investigate issues of environmental impact	Apply science principles to environmental issues			
Unit 1.																
Unit 2.																
Unit 3.																
Unit 4.																
Unit 5.																
Unit 6.																

BASIC SKILLS MATRIX

Oral Communication Skills

UNITS OF INSTRUCTION	Oral Presentation									Listening				Interactive Communication									
	Make informative presentations	Make persuasive presentations	Present personal opinion/viewpoint	Use good speaking techniques	Select/use words effectively	Use effective body language	Present appropriate appearance	Integrate audio and/or visual materials into oral presentations	Adapt presentation to specific audience	Apply active listening skills	Distinguish fact, opinion, and inference	Draw conclusions/make generalizations	Analyze/identify point of view	Give/follow oral directions	Apply questioning techniques	Conduct/receive interviews	Analyze/apply nonverbal communication	Work effectively in a group	Communicate with clients/customers/patients	Communicate with co-workers	Communicate with supervisors	Communicate with professional colleagues/associates	Apply telephone etiquette
Unit 1.																							
Unit 2.																							
Unit 3.																							
Unit 4.																							
Unit 5.																							
Unit 6.																							

BASIC SKILLS MATRIX

Interpersonal or Relating Skills

UNITS OF INSTRUCTION	General Relating											
	Investigate/apply communication process models	Analyze/apply nonverbal communication	Investigate/apply cross-cultural communication	Interact with co-workers	Interact with supervisors	Interact with clients/customers/patients	Interact with professional colleagues/associates	Interact with family/friends	Participate in group activities	Participate in industrial relations/functions	Identify personal values/attitudes	Apply information to life experiences
Unit 1.												
Unit 2.												
Unit 3.												
Unit 4.												
Unit 5.												
Unit 6.												

UNITS OF INSTRUCTION	Teamwork/Cooperation														
	Identify values/attitudes	Identify needs/drives	Select/apply appropriate behavior	Investigate/identify personal styles	Investigate/identify group/corporate climate	Give/receive feedback	Identify hidden purposes	Investigate/apply group dynamics	Control undesirable/inappropriate behavior	Resolve conflicts	Clarify goals/objectives	Devise "win/win" situations	Build consensus	Generate ideas	Present point of view
Unit 1.															
Unit 2.															
Unit 3.															
Unit 4.															
Unit 5.															
Unit 6.															

BASIC SKILLS MATRIX

Interpersonal or Relating Skills (continued)

Leadership/Influence

UNITS OF INSTRUCTION	Analyze/apply leadership styles	Analyze/apply management styles	Obtain confidence of others	Develop esteem in self/others	Persuade others	Analyze/apply motivation techniques	Provide positive coaching																	
Unit 1.																								
Unit 2.																								
Unit 3.																								
Unit 4.																								
Unit 5.																								
Unit 6.																								

BASIC SKILLS MATRIX

Critical Thinking

Cognitive Activities

UNITS OF INSTRUCTION	Collect/record information	Identify critical elements/issues	Define a problem	Identify underlying causes	Apply a problem-solving model	Analyze/synthesize information	Identify/analyze underlying assumptions	Draw conclusions	Predict results/outcomes	Identify/evaluate consequences	Identify/develop alternatives	Evaluate alternatives	Select an alternative	Devise a solution	Create a finished product	Apply intuitive thinking techniques	Transfer knowledge/training to new situations	Apply new technology	Develop an action plan	Evaluate results/outcomes
Unit 1.																				
Unit 2.																				
Unit 3.		X						X												
Unit 4.		X		X	X	X		X	X		X	X								
Unit 5.																				
Unit 6.																				

BASIC SKILLS MATRIX

Employability Skills

	Job Search/Selections					Job Acquisition/Development																
UNITS OF INSTRUCTION	Analyze personal occupational aptitudes/preferences	Investigate employment prospects of a career field/occupation	Investigate training requirements for a career field/occupation	Investigate benefits of a career field/occupation	Compare/evaluate career options	Develop personal career path	Locate appropriate jobs	Analyze duties/requirements/benefits of specific job	Master specific job task/procedure	Complete job-related applications	Write a letter of application	Write personal resume	Interview for a job	Apply business etiquette	Practice good work habits/attitudes	Practice good personal presentation	Develop self confidence/esteem	Develop effective leadership	Deal effectively with supervisors	Deal effectively with co-workers	Deal effectively with professional colleagues/associates	Deal effectively with customers/clients/patients
Unit 1.																						
Unit 2.									X						X		X					
Unit 3.																						
Unit 4.									X						X		X					
Unit 5.									X						X		X					
Unit 6.																						

BASIC SKILLS MATRIX

Social Studies Skills

UNITS OF INSTRUCTION	Information Analysis						Social Studies Application														
	Collect/record data	Interpret graphical information	Construct graphical information	Interpret maps/globes	Interpret statistical information	Analyze/Interpret demographic information	Investigate/apply U.S. history	Investigate/apply world history	Investigate/apply U.S. geography	Investigate/apply world geography	Investigate/apply principles of government/politics	Investigate/apply principles of economics	Investigate/apply principles of ethics	Investigate/apply principles of psychology	Investigate/apply principles of sociology	Investigate/apply cross-cultural studies					
Unit 1.																					
Unit 2.																					
Unit 3.																					
Unit 4.																					
Unit 5.																					
Unit 6.																					

BASIC SKILLS MATRIX

Social Studies Skills

(continued)

	Functional Social Studies																			
UNITS OF INSTRUCTION	Practice responsible personal economics	Prepare a personal budget	Use credit responsibly	Practice good work ethics	Participate in industrial relations	Interact with people of different races/cultures	Investigate/participate in government	Investigate/apply American legal practices	Select/use sources of information on current events	Analyze current events	Analyze consumer issues	Analyze social issues	Analyze conservation/ecology issues	Analyze social impact of science/technology	Analyze economic impact of science/technology						
Unit 1.																					
Unit 2.																					
Unit 3.																					
Unit 4.																					
Unit 5.																					
Unit 6.																					

Tools, Equipment, and Materials List

- Appliance
  - Cord
  - Fixed, with pigtail
- Awl
- Bar hanger
- Bulb
  - 120V
  - Incandescent, 120V
- Boxes - various sizes
  - Fan
  - Octagon
  - One-gang
  - Two-gang
- Bushings, insulating
- Cable - various lengths
  - NM, 12-2-G or 14-2-G
  - NMB, 12-3-G or 14-3-G
  - SE
  - TW, copper, #2 and #4
  - Telephone wire, 2 or 4 pair
  - Bell wire, 18-3 and 18-2
- Ceiling fan w/light kit
- Chime, with front and back call
- Circuit tester
- Clamps, cable
- Conduit
  - Nonmetallic tubing (PVC)
  - Rigid metal, raintight fusible
- Connectors
  - Cable
  - Service
  - Wire
- Door bell buttons
- Drill
- Drop cloth
- Duplex grounding type receptacle
- Electrical supply, 120V
- Extension Cord
- Fasteners
- GFCI, portable
- Hacksaw
- Hacksaw blade
- Hammer
  - Electrician's

Tools, Equipment, and Materials List

- Header board
  - 1″x6″,or 2″x4″
- Knife
  - Electricians
  - Pocket
- Level
- Light socket
- Load center, rainproof
- Locknuts
- Meter base
- Nails
  - 16 penny
  - Plasterboard
- Nipple, reamed
- Nut driver set
- Pencil
- Plaster rings
- Pliers
  - Lineworkers
  - Long nose
  - Needle nose
- Pouch tools
- PVC
  - Coupling
  - 90 degree elbow
  - Male adapter
- Range, free standing
- Receptacle, 30A or 50A
- Rule, folding with sliding scale
- Safety glasses
- Screwdrivers
  - Flat blade
  - Plain tip
- Screws
  - Metal tapping
  - Wood
- Service entrance cap, 1 1/2″ clamp-on
- Smoke detectors, 2
- Staples
- Strap, rigid conduit
- Switch
  - Single pole
  - Three-way
  - Four-way
  - Safety, raintight fusible
- Tape measure
- Telephone wall plates, (2)
- Tool pouch
- Transformer, 16V

- Wall
  - Mock-up
  - Stud
- Wire strippers
- Wood bit, 1/2″ or larger

Unit 1

Blueprint Reading and Load Calculations

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 1–3

Answers to Assignment Sheets 1–7

Written Test 1–9

Answers to Written Test 1–15

Learning Activities Sheet 1–17

Teacher Supplements

- 1—Electrical Floor Plan 1–19

Student Components

Student Page

Objective Sheet 1–3

Information Sheet 1–5

Student Supplements

- 1—Calculating Square Footage 1–15

Assignment Sheets

- 1—Draw Receptacle and Lighting Outlets on a Floor Plan 1–17
- 2—Determine General Lighting Loads 1–19
- 3—Determine Small Appliance and Laundry Loads 1–21
- 4—Determine Total Connected Load Plus Total Demand Load of a Dwelling 1–23
- 5—Locate Required Receptacle and Lighting Outlets on a House Plan 1–25

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.

Suggested Activities

- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Teaching Suggestions

- Collect and distribute to the class a number of blueprint and specification plans from local contractors. Have students practice interpreting the symbols on the plans. As students progress through instruction, they can also perform load calculations on these plans.
- Contact a local contractor and invite her/him to class to discuss how to read blueprints and why they are important on the job. Have students prepare questions in writing beforehand and provide to speaker so that he/she will come prepared to respond to those questions when asked by students. Provide students with the compiled list of questions so that they may record the answers for future use.
- Invite a local representative of the electrical inspection authority to visit the class to discuss the local code restrictions and how they affect the load calculations derived from blueprint specification plans. Have students review local code requirements and prepare questions they would like to ask. Provide students with list of questions so that they can record the answers for future use.
- Have students organize into separate groups and have each group design and draw to scale, a room or section of a house plan.

  Example: Group 1 will design and draw the kitchen dining room area of the house plan complete with symbols and dimensions. Group 2 will design and draw the master bedroom and master bath area. Group 3 will design and draw the living room and garage area. All groups should draw their areas to scale and provide necessary symbols and specifications. A completed drawing may then be assembled and load calculations made from the composite drawing and specifications.
- Make copies of Teacher Supplement 1 to distribute to class following their completion of Assignment Sheet 5. This supplement serves as the answer sheet to the assignment, and students can evaluate their performance.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Gebert, Kenneth L. *Blueprint Reading*, 9th ed. Alsip, IL: American Technical Publishers, Inc., 1983.
- *1999 National Electrical Code®*. Quincy, MA: National Fire Protection Association, 1998.
- Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1988.
- *1993 National Electrical Code®*. Quincy, MA: National Fire Protection Association, 1993.

Suggested Supplemental Resources

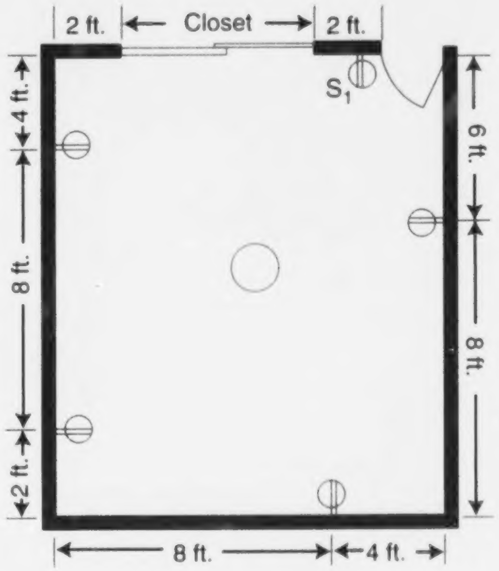
Print Media

- Huth, Mark. *Understanding Construction Drawings*, 2nd ed. Albany, NY: Delmar Publishers, Inc., 1996.
- Mullin, Ray C. *Electrical Wiring: Residential*, 13th ed. Albany, NY: Delmar Publishers, Inc., 1999.
- O'Riley, Ronald P. *Illustrated Changes in the 1999 National Electrical Code*. Albany, NY: Delmar Publishers Inc., 1999.

Answers to Assignment Sheets

Assignment Sheet 1

Draw Receptacle and Lighting Outlets on a Floor Plan



Note: This answer represents one possible solution.

Assignment Sheet 2

Determine General Lighting Loads

1. 3200 sq. ft. x 3 VA = 9600VA
2. 2750 sq. ft. x 3VA = 8250VA
3. 4100 sq. ft.
   - 480 sq. ft. garage
   3620 sq. ft.

   24 ft.
   x 20 ft.
   480 sq. ft. garage

   3620 sq. ft. x 3VA = 10,860VA
4. 1925 sq. ft.
   - 70 sq. ft. porch
   1855 sq. ft.
   1855 sq. ft. x 3VA = 5,565VA

   10 ft.
   x7 ft.
   70 sq. ft. porch

Assignment Sheet 3

Determine Small Appliance and Laundry Loads

1.	Small appliance circuits	2 circuits x 1500VA = 3000VA
	Laundry circuits	1 circuit x 1500VA = 1500VA
	Total small appliance and laundry loads	3 circuits x 1500VA = 4500VA

2.	Small appliance circuits	4 circuits x 1500VA = 6000VA
	Laundry circuits	1 circuit x 1500VA = 1500VA
	Total small appliance and laundry loads	5 circuits x 1500VA = 7500VA

Assignment Sheet 4

Determine Total Connected Load Plus Total Demand Load of a Dwelling

1.	2400 sq. ft. x 3 VA	=	7,200 VA
2.	2 small appliance circuits x 1500 VA	=	3,000 VA
3.	1 laundry circuit x 1500 VA	=	1,500 VA
	Total connected load	=	11,700 VA
4.	1st 3000 x 100%		3,000 VA
	Remaining 8700 x 35%		3,045 VA
	Total demand load	=	6,045 VA

Assignment Sheet 5

Locate Required Receptacle and Lighting Outlets on a House Plan

1. See Teacher Supplement 1 for detailed outlet layout. This assignment may be evaluated by either the instructor or student. (See Teaching Suggestion 5.)

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to blueprint reading and load calculations with their definitions. Write the correct numbers in the blanks.

1. Blueprint
2. Blueprint lines
3. Branch circuit
4. Dwelling
5. Feeder circuit
6. Lighting outlet
7. Receptacle outlet
8. Service entrance
9. Specification
10. Symbol
11. Voltage drop

_____ a. A set of conventional symbols to depict an object

_____ b. One or more rooms used for eating, living, and sleeping with permanent provisions for cooking and sanitation

_____ c. An outlet intended for the direct connection of a lampholder or light fixture

_____ d. A detailed set of written instructions which explains the drawing and becomes part of the contract

_____ e. A reduction in available voltage at the end of a circuit

_____ f. Copy of the original detailed drawings of a structure

_____ g. An outlet where one or more receptacles are installed

_____ h. All circuit conductors between the service equipment or the source of a separately derived system and final branch circuit overcurrent device

_____ i. An arbitrary sign that has been standardized and is used to represent an object, quantity, or method

_____ j. The circuit that extends from the last overcurrent protection device to the outlets

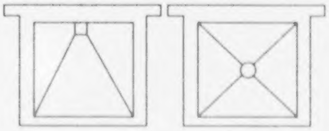
_____ k. The conductors and equipment for delivering electricity from the supply system to the wiring system of the premises served

Written Test

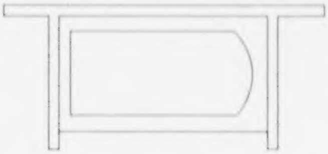
Objective 2

Identify blueprint symbols used in residential drawings. Write your answers in the blanks provided.

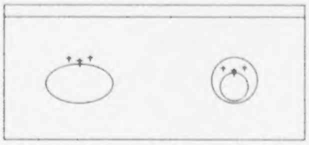
a. Plumbing



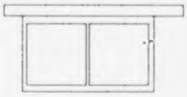
1. ______________________



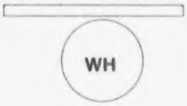
2. ______________________



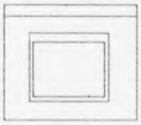
3. ______________________



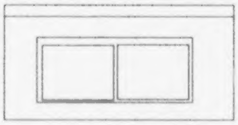
4. ______________________



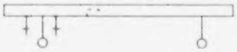
5. ______________________



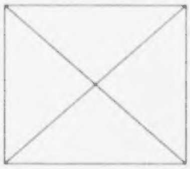
6. ______________________



7. ______________________

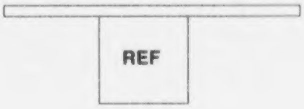


8. ______________________

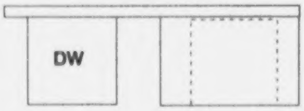


9. ______________________

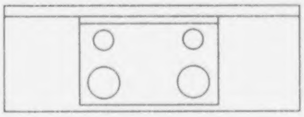
b. Appliances



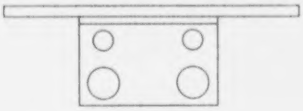
1. ____________________



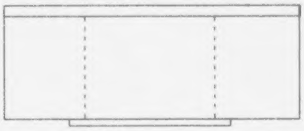
2. ____________________



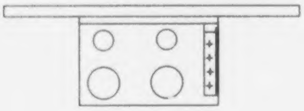
3. ____________________



4. ____________________

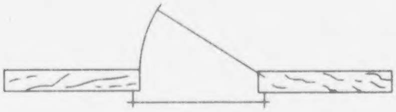


5. ____________________

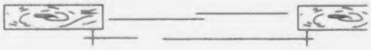


6. ____________________

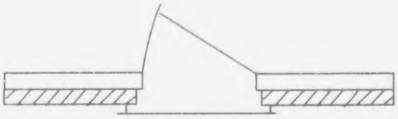
c. Structural symbols



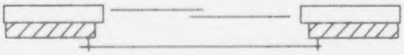
1. ____________________



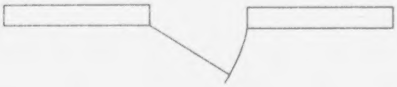
2. ____________________



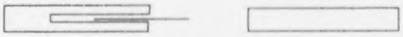
3. ____________________



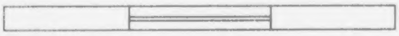
4. ____________________



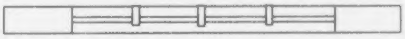
5. ____________________



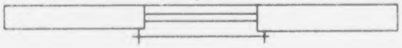
6. ____________________



7. ____________________



8. ____________________



9. ____________________

Written Test

Objective 3

Match the electrical symbols with their definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

______ a. Ceiling outlet

______ b. Range outlet

______ c. Double pole switch

______ d. Fluorescent fixture

______ e. Lighting panel

______ f. Branch circuit; exposed

______ g. Duplex receptacle

______ h. Ground

______ i. Floor outlet

______ j. Momentary contact switch

______ k. Power panel

______ l. Four-way switch

______ m. Dimmer switch

______ n. 240V, 3w, 2p receptacle

______ o. Switch and convenience outlet

______ p. Branch circuit; concealed in ceiling or wall

______ q. Fuse

______ r. Junction box

______ s. Switch and pilot light

______ t. Feeders

______ u. Circuit breakers

______ v. Motion sensor switch

______ w. Home run to panel board

______ x. 120/240, 1ø combination receptacle

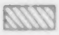
______ y. Thermostat

______ z. Recessed incandescent

______ aa. Electronic smoke detector

______ bb. Cable TV outlet

______ cc. Phone outlet

1. 

2. S_2

3.

4. S_4

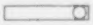
5. S_D

6.

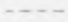
7. Sp

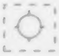
8. S_{MC}

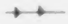
9.

10. 

11.

12. 

13. 

14. 

15.

16.

17.

18.

19.

20.

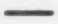
21.

22.

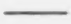
23.

24.

25.

26. 

27.

28. 

29. S_{MS}

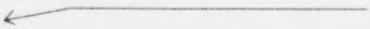
Written Test

Objective 4

Match the types of lines with their correct definitions. Write the correct numbers in the blanks.

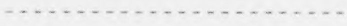
1. Object lines
2. Center lines
3. Leaders
4. Cutting-plane lines
5. Hidden lines
6. Dimension lines
7. Break lines

_____ a.



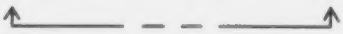
Used to connect a note or dimension to a part of the building

_____ b.



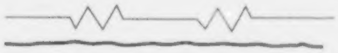
Short dashes used to show lines that are not visible from that view

_____ c.



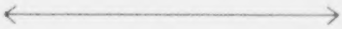
Heavy lines consisting of a series of one long and two short dashes with arrows at each end pointing away from the area that is cut away for the purpose of sectioning

_____ d.



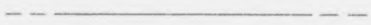
Used when an area cannot or should not be drawn entirely

_____ e.



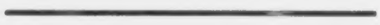
Thin broken lines which building dimensions are placed upon

_____ f.



A series of short and long dashes used to designate the center of doors, windows, and circles and to provide a reference point for dimensioning

_____ g.



Show the main outline of the building including exterior walls, interior partitions, porches, patios, driveways, and interior walls; these lines should be the outstanding lines on a drawing

Objective 5

List five kinds of information commonly found in blueprint specifications.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

Written Test

Objective 6

Select true statements concerning minimum requirements for residential outlets by placing an "X" in the blanks next to the true statements.

______ a. Receptacles—Installed so that no point along the floor line in any wall space is more than 4 feet from an outlet

______ b. Switches—Located so that they may be operated from a readily accessible place

______ c. Lighting—At least one wall switch controlled lighting outlet shall be installed in every habitable room, hall, stairway, attached garage, bathroom, and outdoor entrance to a residence

Objective 7

Calculate circuit loads and voltage drop for the example below.

Dwelling has a floor space of 2,100 square feet. It also has an 11 kw electric range.

General lighting load

a. ______ sq. ft. x 3 watts per sq. ft. = b. ______

Minimum number of branch circuits

General lighting load c. ______ ÷ 120 = d. ______ ÷ 20 =

e. ______ or number of general lighting circuits

Note: This number always rounds to next whole number if a fraction appears.

Small appliance load: Two 2-wire 20 ampere circuits.

Laundry load: One 2-wire 20- ampere circuit

Minimum size feeders required

Computed load

General lighting	f. ______	watts
Small appliance	+3,000	watts
Laundry	+1,500	watts
Total (without range)	g. ______	watts
3,000 watts at 100% =	3,000	watts
Total (without range) h. ______ -		
3,000 = ______ watts x 35% =	i. ______	watts
Net computed load (without range)	j. ______	watts
Range load	8,000	watts
Net computed load (with range)	k. ______	watts

A branch circuit conductor with a resistance of 1.93 ohm per mft. is installed at a length of 110 ft. This circuit has a load current of 12 amps. Calculate the voltage drop for this circuit.

l. ______

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 2
b. 4
c. 6
d. 9
e. 11
f. 1
g. 7
h. 5
i. 10
j. 3
k. 8

Objective 2

a. Plumbing
   1) Showers
   2) Built-in bathtub
   3) Built-in lavatories
   4) Laundry tubs
   5) Water heater
   6) Single bowl sink
   7) Double bowl sink
   8) Shower heads
   9) Furnace

b. Appliances
   1) Refrigerator
   2) Dishwasher (freestanding or built-in)
   3) Drop-in range
   4) Free standing range
   5) Built-in oven
   6) Surface cook top

c. Structural symbols
   1) Exterior door in wood frame wall
   2) Exterior sliding door in wood frame wall
   3) Exterior door in masonry veneer wall
   4) Exterior sliding door in masonry veneer wall
   5) Interior hinged door
   6) Interior pocket door
   7) Single window in frame wall
   8) Multiple windows in frame wall
   9) Double hung window in frame wall

Objective 3

a. 3
b. 15
c. 2
d. 10
e. 21
f. 12
g. 17
h. 22
i. 20
j. 8
k. 1
l. 4
m. 5
n. 23
o. 16
p. 28
q. 25
r. 11
s. 7
t. 26
u. 24
v. 29
w. 14
x. 19
y. 27
z. 13
aa. 18
bb. 6
cc. 9

Answers to Written Test

Objective 4

a.	3	e.	6
b.	5	f.	2
c.	4	g.	1
d.	7		

Objective 5

Any five of the following:

a. Sizes
b. Types and quality of building materials
c. Methods of construction
d. Material lists
e. Owner's name and address
f. Contractor's name and address
g. Location of new structure
h. Completion date
i Contractor's bid
j. Guarantees
k. Blueprint number

Objective 6

b, c

Objective 7

a.	2,100	e.	3	i.	2,730
b.	6,300	f.	6,300	j.	5,730
c.	6,300	g.	10,800	k.	13,730
d.	52.5	h.	10,800	l.	5.095

Unit 1

Blueprint Reading and Load Calculations

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet

☐ 3. **Study** Information Sheet, Objectives 1 through 7.

☐ 4. **Do** Assignment Sheet 1, Draw Receptacle and Lighting Outlets on a Floor Plan."

☐ 5. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 6. If the evaluation is not satisfactory, repeat Steps 3 and 4.

☐ 6. **Study** Student Supplement 1, "Calculating Square Footage."

☐ 7. **Do** Assignment Sheet 2, "Determine General Lighting Loads."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat Steps 3 and 7.

☐ 9. **Do** Assignment Sheet 3, "Determine Small Appliance and Laundry Loads."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 3 and 9.

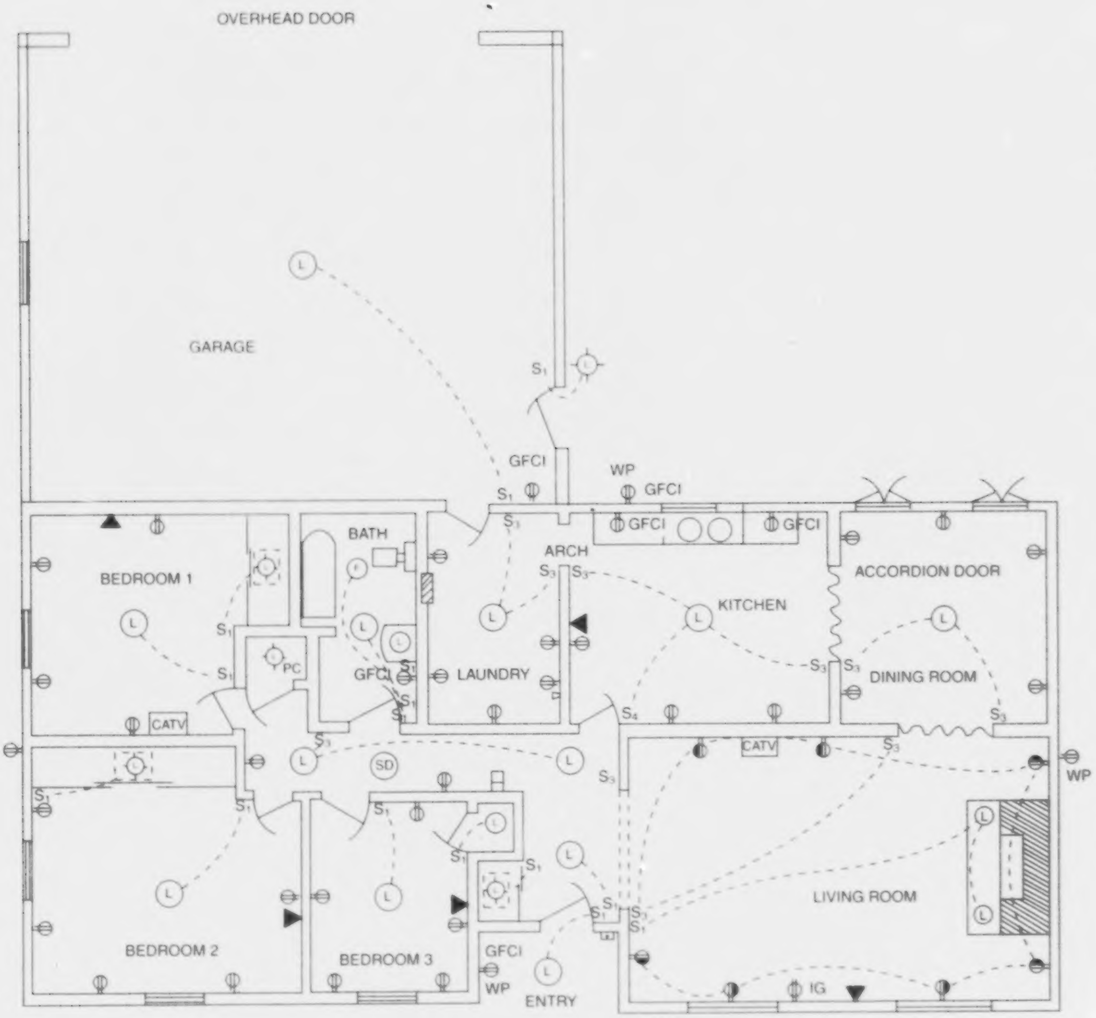
☐ 11. **Do** Assignment Sheet 4, "Determine Total Connected Load Plus Total Demand Load of a Dwelling."

Learning Activities Sheet

☐ 12.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, repeat Steps 3 and 11.
☐ 13.	**Do**	Assignment Sheet 5, "Locate Required Receptacle and Lighting Outlets on a House Plan."
☐ 14.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 15. If the evaluation is not satisfactory, repeat Steps 3, 6, and 13.
☐ 15.	**Check**	With instructor for any additional assignments to be completed.
☐ 16.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
☐ 17.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Teacher Supplement 1—Electrical Floor Plan


OVERHEAD DOOR
GARAGE
S_1
GFCI
WP
GFCI
BATH
ARCH
GFCI
GFCI
ACCORDION DOOR
BEDROOM 1
KITCHEN
PC
LAUNDRY
DINING ROOM
CATV
SD
CATV
WP
LIVING ROOM
BEDROOM 2
BEDROOM 3
GFCI
WP
ENTRY
IG

Electrical Floor Plan

*Permission to duplicate this plan is granted.

Unit Contents

Teacher Components

Teacher Page

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Answers to Assignment Sheets 2–7

Written Test 2–9

Answers to Written Test 2–15

Learning Activities Sheet 2–17

Transparency Masters

- 1—Parts of a Service Entrance 2–19
- 2—Parts of a Service Entrance–Continued 2–21
- 3—Parts of a Service Entrance–Continued 2–23
- 4—Installing a Grounding Rod 2–25

Student Components

Student Page

Objective Sheet 2–3

Information Sheet 2–5

Assignment Sheet

- 1—Calculate Service Size and Minimum Number of Circuits 2–15

Job Sheets

- 1—Install an Overhead Raceway with Service Entrance Conductors to a Meter Base. 2–17
- 2—Connect Meter Base Assembly to Load Center or Panel 2–21
- 3—Install an underground Service (Lateral) Raceway with Conductors to a Meter Base 2–25
- 4—Braid the Ground Conductor of a Service Entrance Cable 2–27

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1—Parts of a Service Entrance (Objective 5)
TM 2—Parts of a Service Entrance—Continued (Objective 5)
TM 3—Parts of a Service Entrance—Continued (Objective 5)
TM 4—Installing a Grounding Rod (Objective 6)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Have students review Unit 10: Overcurrent Protection in Basic Wiring.
- Contact a local sales distributor and invite him/her to class to discuss and demonstrate fuses and circuit breaker types. Have students prepare questions in writing beforehand and provide to speaker so that he/she will come prepared to respond to those questions when asked by the students. Provide students with the compiled list of questions so that they may record the answers for future use.
- Invite a local utility representative to class to discuss local requirements for service and meter demonstration. Have students review local code requirements and prepare questions that they would like to have answered by guest speaker. Provide students with the compiled list of questions so that they may record the answers for future use.
- Contact your local code enforcement (inspection) department to schedule a class presentation concerning local regulations and requirements for service installation and grounding. This activity may be combined with the previous suggestion. so that discussion can be interactive among speakers and students.
- If possible, plan an on-site visit to a residence under construction to see rough-in of service installation—underground or overhead or both. Have students take notes on what they observe, then discuss their observations in class.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

Suggested Activities

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- *Buss Fuses—Full Line Condensed Catalog*. St. Louis, MO: Bussman Division, McGraw Edison Company.
- *D Digest 1987*. Palatine, IL: Square D Company.
- Earl, John T. *Electrical Wiring Design and Application*. Englewood Cliffs, NJ: Prentice Hall, 1986.
- Gray, Elliott C., R. Bailey, and E. Melbourne. *Electrical Construction and Maintenance Techniques*. Englewood Cliffs, NJ: Prentice Hall, 1986.
- Mullin, Ray C. *Electrical Wiring: Residential*, 11th ed. Albany, NY: Delmar Publishers Inc., 1993.
- *1993 National Electrical Code®*, Quincy, MA: National Fire Protection Association, 1992.
- *Pass and Seymour—Wiring Devices Catalog #486*. Syracuse, NY.
- Richter, Herbert P. and W. Creighton Schwan. *Practical Electrical Wiring*, 15th ed. Englewood Cliffs, NJ: Prentice Hall, 1990.
- Stallcup, James G. *Designing Electrical Systems Based on the 1990 NEC*. Homewood, IL: American Technical Publishers, Inc., 1989.
- Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1988.
- *National Electrical Code, 1999*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- Mullin, Ray C. *Electrical Wiring: Residential*, 13th ed. Albany, NY: Delmar Publishers, Inc., 1998.

Electronic Media

- Residential Wiring Series

  This is a 4-part series. Two of the titles are recommended for this unit.

  — National Electrical Code (17 minutes)
  — Installing the Electrical Service (20 minutes)

- Residential Wiring: Special Purpose Circuits (3-part series; 20 minutes each)

  Students will understand that although each circuit is energized through the main service panel, there are reasons why an additional panel may be necessary. How to calculate and install the circuit is demonstrated.

  Note: Both series are available in VHS or CD ROM format. Order from Bergwall Production Inc., 8 Ponds Edge Drive, Chadds Ford, PA., 19317-0804, call 800-645-3565, or visit www.bergwall.com.

Answers to Assignment Sheets

Assignment Sheet 1

Calculate Service Size and Minimum Number of Circuits

1. 2100 Sq. Ft.
2. 6300 VA
3. 6300 VA
4. 53 Amperes
5. 3
6. 6300 VA
7. 10800
8. 18800
9. 5730
10. 8530
11. 5730
12. 24 (100)
13. 8530
14. 36 (100)
15. #8
16. #10

Written Test

Name ____

Date ______________________________ Score ____________

Objective 1

Match the terms related to service with their definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Cutout box
2. Service entrance conductors, underground system
3. Service cable
4. Service entrance conductors, overhead system
5. Overcurrent protection
6. Roof flashing
7. Service drop
8. Service conductors
9. Disconnecting means
10. Service
11. Circuit breaker
12. Grounding electrode conductor
13. Service equipment
14. Service lateral
15. Service mast
16. Service raceway
17. Short circuit
18. Sub-panel
19. Main panel

_____ a. Weak link in the circuit that limits the amperage to a specified amount

_____ b. The conductors from the service point to the service disconnecting means

_____ c. An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper

_____ d. The overhead service conductors from the last pole or aerial support to and including the splices, if any, connecting to the service entrance conductors at the building or other structure

_____ e. Service conductors between the terminals of the service equipment and the point of connection to the service lateral

_____ f. Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage

_____ g. Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop

_____ h. Service conductors made up in the form of a cable

Written Test

_____ i. A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

_____ j. Conductor used to connect the grounding electrode to the equipment grounding conductor and/or the grounding conductor of the circuit at the service

_____ k. The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

_____ l. That portion of the service raceway that extends through a roof or eave

_____ m. Consists of a main breaker or pair of fuses. The service conductors enter the service main panel directly from the meter enclosure. The main panel must be located in an accessible place and as close as possible to the point where the service conductors enter the structure.

_____ n. The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and accessories, connected to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply

_____ o. Underground service conductors between the street main, including any risers at a pole or other structure or from transformers and the first point of connection, to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall

_____ p. A device designed to open and close a circuit by non-automatic means, and to open the circuit automatically on a pre-determined overcurrent without damage to itself when properly applied within its rating

_____ q. Unintentional contact of a conductor

_____ r. Raceway that encloses the service entrance conductors

_____ s. A panel deriving from the main panel to service another area or building. This panel does not have the service conductors connected

Objective 2

Match the required clearances for service drop conductors with their various construction locations. Write the correct numbers in the blanks.

1. 3′	3. 10′	5. 15′
2. 18″	4. 12′	6. 18′

_____ a. At the electric service entrance to buildings, or at the drip loop of the building electric entrance, measured from final grade or at the accessible surface

_____ b. Over a roof with a slope of not less than 4″ in 12″ on systems which do not exceed 300V between conductors

_____ c. For those areas listed in the 12 foot (3.66m) classification where voltage exceeds 300 volts to ground

_____ d. Over public streets, alleys, roads, and nonresidential driveways

_____ e. If the conductors do not pass over more than 6′ of overhang and are terminated at a through-the-roof raceway or support on a system which does not exceed 300V between conductors

_____ f. For those areas where the voltage is limited to 300V to ground

Objective 3

Select true statements concerning service disconnects by placing an "X" in the blanks next to the true statements.

_____ a. Not more than seven switches or circuit breakers are allowed in a single enclosure or grouped on a switch board.

_____ b. The transfer switch must disconnect the main service before connecting the alternate source.

_____ c. The transfer switch may be manually or automatically operated.

Objective 4

List four facts that should be known before the service installation is started.

a. ____________________

b. ____________________

c. ____________________

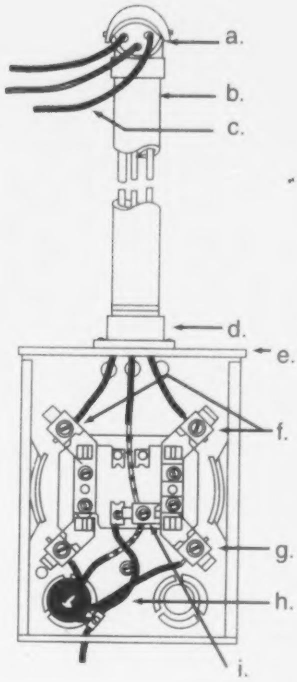
d. ____________________

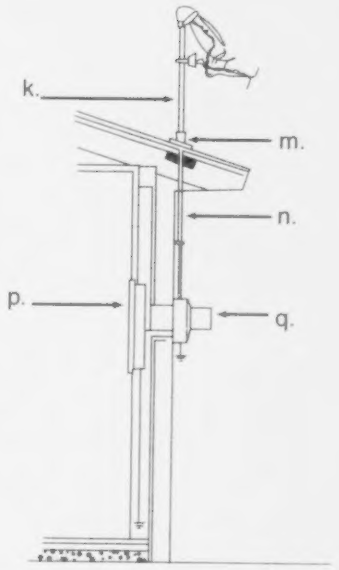
Written Test

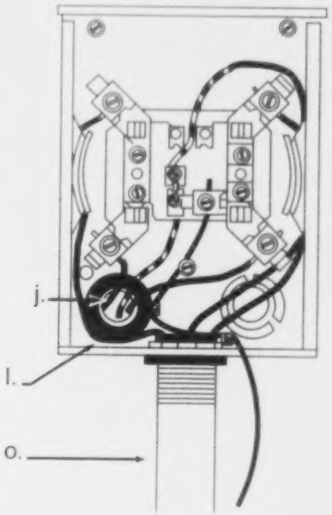
Objective 5

Identify the parts of a service entrance.

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________
h. ____________________
i. ____________________
j. ____________________
k. ____________________
l. ____________________
m. ____________________
n. ____________________
o. ____________________
p. ____________________
q. ____________________







Objective 6

Select from the following list, types of grounding electrodes by placing an "X" in the blanks preceding the correct types.

_____ a. Water pipe

_____ b. 8′ length of 5/8″ iron or steel rod

_____ c. Nearest effectively grounded structural metal member of the structure

_____ d. 8′ length of 1/2″ galvanized pipe

_____ e. At least 10′ of bare copper conductor not smaller than No. 5 AWG or one or more steel reinforced bars or rods of not less than 3/4″diameter encased in at least 2″ of concrete in a foundation or footing

_____ f. A grounding ring encircling the building or structure, in direct contact with the earth at a depth below the earth's surface of not less than 2 1/2 feet (762mm), consisting of at least 20 feet (6.1m) of bare copper conductor not smaller than No. 2.

Objective 7

Select the true statements concerning grounding electrode conductor installations and sizes by placing an "X" in the blanks preceding the true statements.

_____ a. Conductors and enclosures shall be secured to the surface they follow.

_____ b. #6 or larger conductors must be in conduit if subject to physical damage.

_____ c. If free from physical damage, #6 conductors may follow the surface of building if stapled securely.

_____ d. Aluminum or copper clad aluminum may be used in contact with masonry or earth.

Objective 8

Select true statements concerning short circuit protection at service equipment by placing an "X" in the blanks preceding the true statements.

_____ a. Service equipment must be able to withstand the fault-current that the power company's transformer could deliver in case of a short-circuit condition.

_____ b. Overcurrent protection devices must be selected to interrupt instantaneous short-circuit currents.

_____ c. Formulas for short circuit calculations include:

(1) Single phase, $$I = \frac{KVA \times 1000}{E}$$

(1) Three phase, $$I = \frac{KVA \times 1000}{E \times 1.73}$$

Written Test

Objective 9

Select true statements concerning surge protection by placing an "X" in the blanks preceding the true statements.

______ a. Voltage surges with peaks of several thousand volts, even on 120V circuits, are uncommon.

______ b. Surges occur because of induced voltages in power lines resulting from lightning strikes in the vicinity of the line.

______ c. Lightning surge arresters allow the passage of current to ground as long as the voltage is normal.

______ d. When the voltage rises to a definite amount above normal, the surge arrester must provide a path to ground for discharge of surge energy.

______ e. Arresters must not be damaged by the discharge and be capable of automatically repeating their actions as frequently as is required.

Objective 10

Calculate the size of service and minimum number of circuits on the following dwelling.

1900 sq. ft. structure with a 12KW range, two small appliance circuits, and one laundry circuit.

a. The general lighting load equals ____________________ VA.

b. The two small appliance circuits equal ____________________ VA.

c. The one laundry circuit equals ____________________ VA.

d. The range load equals ____________________ VA.

e. The total VA equals ____________________ VA.

f. For 120/240 volt 30wire system feeders, the net computed load equals ______________ VA ÷ ______________ volts = ______________ amperes.

g. The minimum size of the service conductor shall be ______________ amperes.

h. What size THHN conductor is required for this problem? ___________ THHN

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 5
b. 8
c. 1
d. 7
e. 2
f. 6
g. 4
h. 3
i. 9
j. 12
k. 10
l. 15
m. 19
n. 13
o. 14
p. 11
q. 17
r. 16
s. 18

Objective 2

a. 3
b. 1
c. 5
d. 6
e. 2
f. 4

Objective 3

b c

Objective 4

a. Whether underground or overhead service will be used
b. Voltage and amperage of service needed
c. Point at which service conductors are to enter the building
d. Size of service equipment needed

Objective 5

a. Service entrance weatherhead or cap
b. Service entrance raceway
c. Service entrance conductors
d. Hub
e. Meter base
f. Line lugs
g. Load lugs
h. Grounding electrode conductor
i. Grounding lugs
j. Service entrance conductors
k. Service mast
l. Service lateral
m. Roof flashing
n. Service entrance raceway
o. Underground service raceway
p. Load center or panel
q. Meter

Objective 6

a, b, c, f

Objective 7

a, b, c

Objective 8

All are correct

Objective 9

b, d, e

Answers to Written Test

Objective 10

a. 1900 x 3 = 5700 VA
b. 1500 x 2 = 3000 VA
c. 1500 x 1 = 1500 VA
d. 220-10 = 8000 VA
e. Total VA = 18,200 VA
f. 18,200 VA ÷ 240 volts = 76 amps
g. 100 amps
h. #4 THHN

Prerequisites:
None

Learning Activities Sheet

Student Name ____________________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 through 9.

Optional

☐ 4. **View** Videotapes entitled: "National Electrical Code" and "Installing the Electrical Service."

☐ 5. **Do** Job Sheets 1 and 2, "Install an Overhead Raceway with Service Entrance Conductors to a Meter Base" and "Connect Meter Base Assembly to Load Center or Panel."

☐ 6. **Stop** Have instructor evaluate your performance after completing each Job Sheet. If the evaluation of Job Sheet 1 is satisfactory, continue to Job Sheet 2. If the evaluation is not satisfactory, study the procedure outline in Job Sheet 1 and reaccomplish that Job Sheet. If the evaluation of Job Sheet 2 is satisfactory, continue to Step 7. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and reaccomplish that Job Sheet.

☐ 7. **Do** Job Sheet 3, "Install an Underground Service (lateral) Raceway with Conductors to a Meter Base."

☐ 8. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 7.

☐ 9. **Do** Job Sheet 4, "Braid the Ground Conductor of a Service Entrance Cable."

Learning Activities Sheet

☐ 10. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 11. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 9.

☐ 11. **Study** Information Sheet, Objective 10.

☐ 12. **Do** Assignment Sheet 1, "Calculate Service Size and Minimum Number of Circuits."

☐ 13. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to Step 14. If the evaluation is not satisfactory, repeat Steps 11 and 12.

Optional

☐ 14. **View** Videotapes entitled: "Residential Wiring: Special Purpose Circuits" (3-part series).

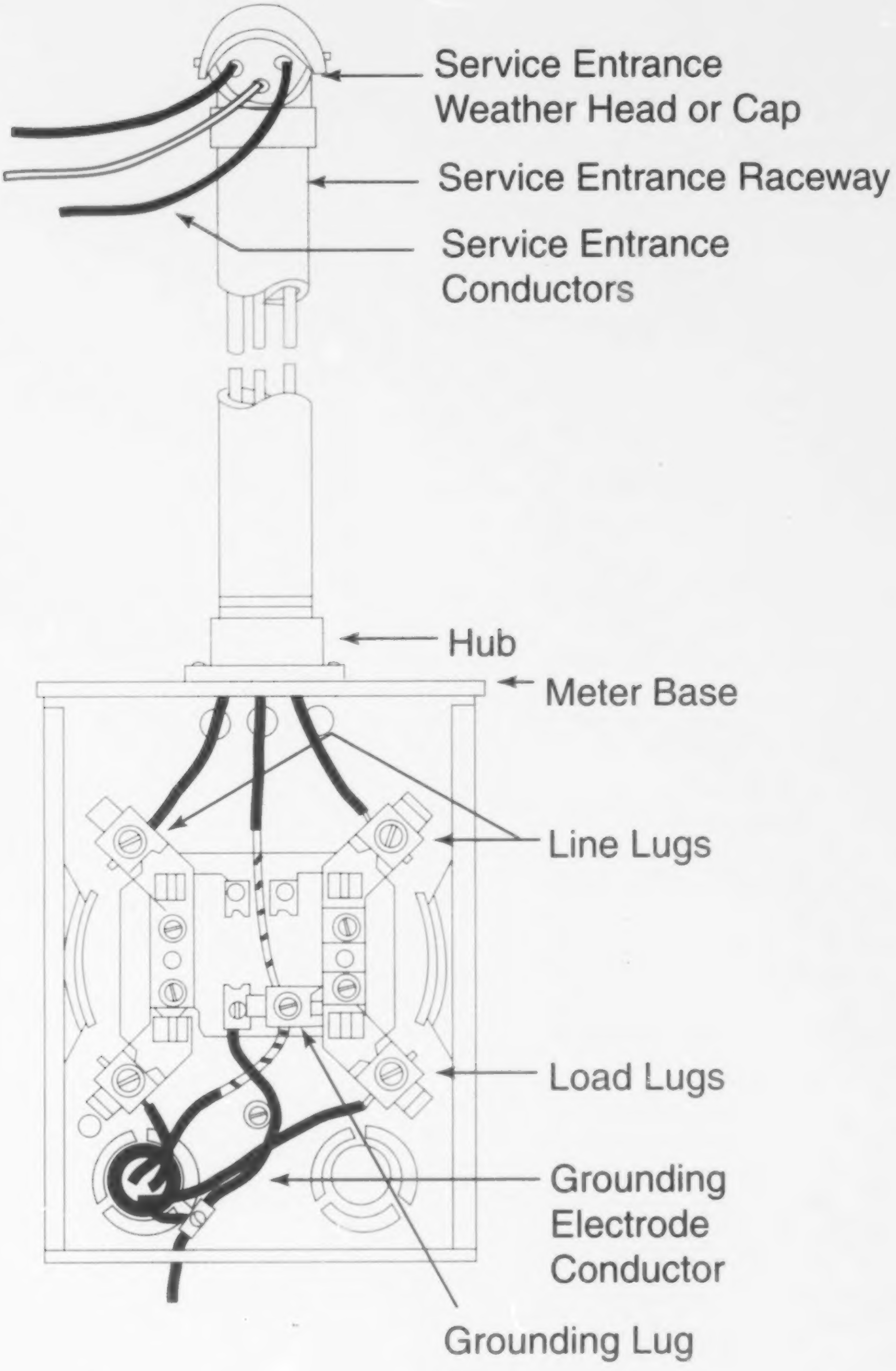
☐ 15. **Check** With instructor for any additional assignments to be completed.

☐ 16. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

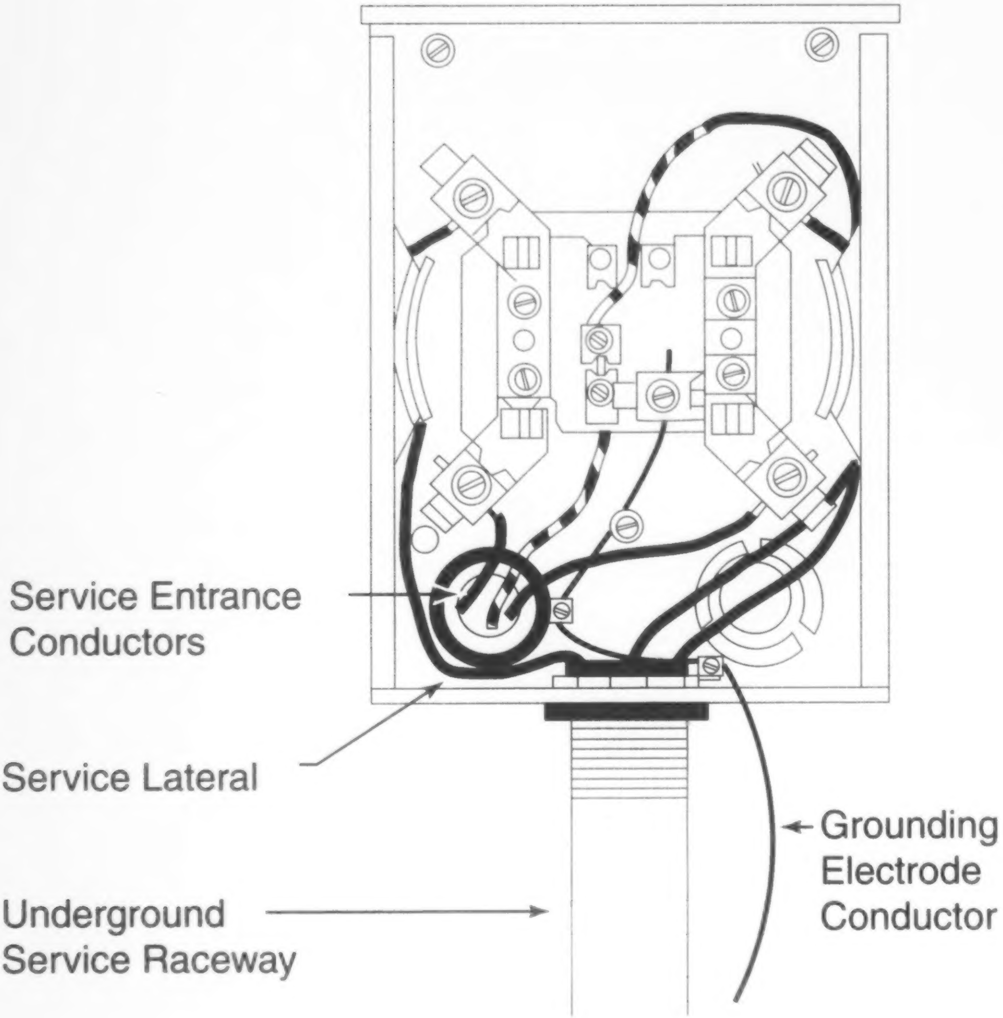
☐ 17. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

*Permission to duplicate this form is granted.

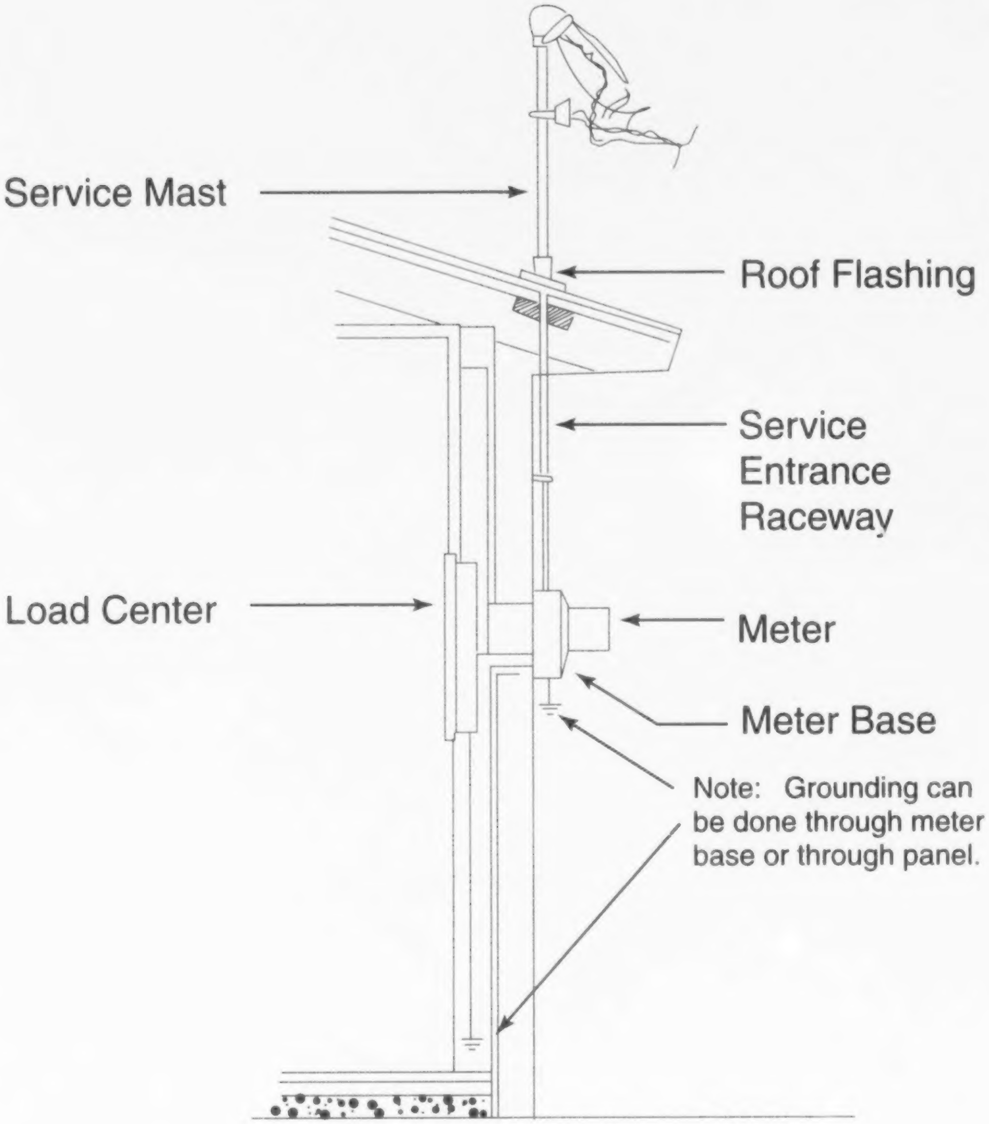
Parts of a Service Entrance


Service Entrance Weather Head or Cap
Service Entrance Raceway
Service Entrance Conductors
Hub
Meter Base
Line Lugs
Load Lugs
Grounding Electrode Conductor
Grounding Lug

Parts of a Service Entrance (Continued)

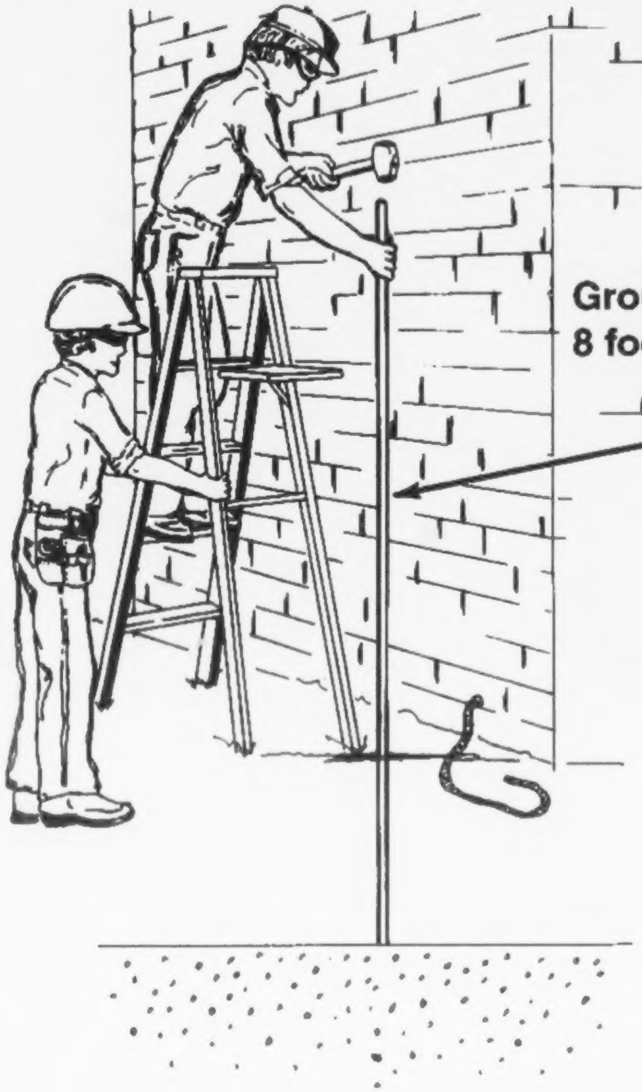

Service Entrance Conductors
Service Lateral
Underground Service Raceway
Grounding Electrode Conductor

Parts of a Service Entrance (Continued)


Service Mast
Roof Flashing
Service Entrance Raceway
Load Center
Meter
Meter Base
Note: Grounding can be done through meter base or through panel.

Note: Check with the local power company for specifications on service mast.

Installing a Grounding Rod



Ground rod must be 8 foot in length

Unit 3 Rough-In

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 3–3

Answers to Assignment Sheets 3–7

Written Test 3–9

Answers to Written Test 3–13

Learning Activities Sheet 3–15

Teacher Supplements

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Transparency Masters

1—Placement of Electrical Outlets in the Kitchen 3–19
2—Box Locations (Outside Entrance and Exit) 3–21
3—Examples of Kitchen Dimensions (For Placement of Boxes) . . . 3–23
4—Flush Box Installation in Brick Veneer 3–25
5—Installing Boxes 3–27
6—Locating Center Points for Ceiling Outlet Boxes 3–29

Student Components

Student Page

Objective Sheet 3–3

Information Sheet 3–5

Focus Assignment

List Systems That Must Be Installed in a Residence Prior to Installing the Wall Finish 3–11

Assignment Sheets

1—Locate Receptacle, Switch, and Lighting Outlets Along a Floor Line and the Ceiling on a Blueprint 3–13
2—Locate Receptacle Outlets Along Kitchen Cabinets 3–15
3—Locate Receptacle Outlets in a Bathroom 3–17

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

TM 1—Placement of Electrical Outlets in the Kitchen (Objective 3)
TM 2—Box Locations (Outside Entrance and Exit) (Objective 3)
TM 3—Examples of Kitchen Dimensions (For Placement of Boxes) (Objective 4)
TM 4—Flush Box Installation in Brick Veneer (Objective 5)
TM 5—Installing Boxes (Objective 6)
TM 6—Locating Center Points for Ceiling Outlet Boxes (Objective 7)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.

Teaching Suggestions

- Have students visit a residential construction site where electrical rough-in is exposed. Provide students with a list of questions for them to answer concerning what they observed at the site. Then have students discuss observations in class.

  Example: At what stage of construction must the house be in before rough-in wiring can begin?
- Invite a local or state inspector to class to talk about area building codes pertaining to the wiring of new dwellings. Have students review local code requirements and prepare questions they would like to have answered by the inspector. Provide inspector and students with a copy of the questions so that the inspector will be prepared to answer the questions and the students will be able to record answers for future use.

  Example: How often must the house be inspected?
- Reinforce safety precautions concerning electrical installations.
- Make extra project assignments to build student's proficiency.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

Suggested Activities

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

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  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

Suggested Activities

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *1993 National Electrical Code®*. Quincy, MA: National Fire Protection Association, 1992.
- Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1988.
- *National Electrical Code, 1999*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- Holzman, Harvey N. *Modern Residential Wiring*. South Holland, IL; Goodheart-Willcox Company, Inc. 1999
- Mullin, Ray C. *Electrical Wiring: Residential*, 13th ed. Albany, NY: Delmar Publishers, Inc., 1998

Answers to Assignment Sheets

Assignment Sheet 1

Locate Receptacle, Switch, and Lighting Outlets Along a Floor Line and the Ceiling on a Blueprint

Evaluated according to the criteria given on the assignment sheet and the minimum requirements as stated in the 1999 *NEC*.

Assignment Sheet 2

Locate Receptacle Outlets Along Kitchen Cabinets

Evaluated according to the criteria given on the assignment sheet and the minimum requirements as stated in the 1999 *NEC*.

Assignment Sheet 3

Locate Receptacle Outlets in a Bathroom

Evaluated according to the criteria given on the assignment sheet and the minimum requirements as stated in the 1999 *NEC*.

Note: Some inspectors may have different views as to whether or not 1 or 2 receptacles will be required. See page 72 of the *NEC Handbook (1999)*, Figure 210.11.

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms related to rough-in with their definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Backsplash
2. Box center
3. Box set out
4. Flush
5. Habitable
6. Room center
7. Tile cap
8. Switch leg
9. Appliance branch circuit

_____ a. Midpoint on a boxes vertical dimension

_____ b. Point in a room that is equal distance from parallel walls

_____ c. That portion of a wall behind the kitchen cabinet, starting at the countertop and ending at the bottom of the wall hung cabinets

_____ d. A 120V branch circuit rated at 1500VA (20 amps) supplying energy to one or more outlets to which appliances are to be connected

_____ e. Final tile in a ceramic backsplash when the tile is terminated at some point up the wall

_____ f. Distance that the box extends past the stud

_____ g. Suitable for people to occupy or live in

_____ h. Even with the surface

_____ i. Conductor that carries electrical energy from the switch to the load

Objective 2

List six locations where at least one receptacle outlet is required.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Written Test

Objective 3

Select true statements concerning planning techniques when placing boxes on plans by placing an "X" in the blanks next to the true statements.

_____ a. Keep spacing even where possible.

_____ b. Put boxes in uneven groups if possible.

_____ c. Check door swing direction so switches are behind doors.

_____ d. Place outside lighting outlets low enough for any fixture.

Objective 4

Complete the following accepted heights for boxes in various locations by circling the numbers which best completes each statement.

a. Above kitchen countertop— (**40″**, **45″**) to box center

b. Above bathroom countertops—(**44″**, **40″**) to box center

c. Receptacles along floor line—(**12″**, **10″**) to box centers

d. Wall switches—(**46″**, **50″**) to box centers

Objective 5

Select true statements concerning the procedure for installing boxes in exterior walls to be brick veneered by placing an "X" in the blanks next to the true statements.

_____ a. Punch a large hole in wall sheeting.

_____ b. Push cable through newly formed hole.

_____ c. Put the cable through the back knockout of your box and secure with a cable clamp.

_____ d. Put screws in the device securing holes.

Objective 6

Distinguish between box extensions for noncombustible and combustible wall surfaces by placing an "X" next to the location for combustible materials.

_____ a. Not more than 1/4″ recess from surface.

_____ b. Flush with or projecting from surface.

Objective 7

List two common methods of finding room centers.

a. ____

b. ____

Objective 8

Select true statements concerning required outlets by placing an "X" in the blanks next to the true statements.

_____ a. In every kitchen, family room, dining room, living room, parlor, library, den, sunroom, bedroom, recreation room, or similar room or area of dwelling units. Receptacles shall be installed so that no point along the floor line in any wall space is more than 6 feet measured horizontally, from an outlet in that space, including any space 2 feet or more in width, space occupied by fixed panels in exterior walls, excluding sliding panels, the space afforded by fixed room dividers such as free-standing bar-type counters or railings. Floor receptacles may be counted as part of the required number of receptacles if located within 18 inches of the wall.

_____ b. In kitchen and dining areas of dwelling units, a receptacle outlet shall be installed at each counter space wider than 12 inches.

_____ c. At least one receptacle outlet shall be installed in a bathroom adjacent to the commode location.

_____ d. At least one receptacle outlets shall be installed outdoors.

_____ e. At least two receptacle outlets shall be installed in laundry areas.

_____ f. At least one wall switch controlling a lighting outlet is required in every habitable room including the hallway, bathroom, stairway, attached garage, outdoor entrance, and in attics, under floor space, utility rooms, and basements if used for storage or if containing equipment requiring service.

Objective 9

List seven locations requiring GFCI protection.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

Written Test

Objective 10

List four rules for electrical installations.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

d. ______________________________

____

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 2
b. 6
c. 1
d. 9
e. 7
f. 3
g. 5
h. 4
i. 8

Objective 2

a. Bathroom—Adjacent to sink
b. Laundry—Within six feet of appliance to be served
c. Outside
d. Basement
e. Attached garage
f. Hallway

Objective 3

a, d

Objective 4

a. 45″
b. 40″
c. 12″
d. 50″

Objective 5

b, c, d

Objective 6

b

Objective 7

a. Corner to corner chalkline and plumb bob transfer
b. Measuring half wall lengths, out at right angles from walls

Objective 8

a, b, f

Objective 9

a. Bathrooms
b. Garages
c. Outdoors
d. Crawl spaces
e. Unfinished basements
f. Kitchens
g. Wet bar sinks

Objective 10

Any four of the following:

a. Always be safety conscious.
b. Do work you will be proud of.
c. Be sure all connections are secure and well insulated.
d. Always be sure that overcurrent protection is matched to your conductor rating.
e. Preform conductors before installing devices.
f. Use appropriate tools.
g. Always meet or exceed *NEC*, state, and local code minimum installation requirements.

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "List Systems that Must Be Installed in a Residence Prior to Installing the Wall Finish."

☐ 4. **Study** Information Sheet, Objectives 1 through 10.

☐ 5. **Do** Assignment Sheet 1, "Locate Receptacle, Switch, and Lighting Outlets Along a Floor Line and the Ceiling on a Blueprint."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Do** Assignment Sheet 2, "Locate Receptacle Outlets Along Kitchen Cabinets."

☐ 8. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, repeat Steps 4 and 7.

☐ 9. **Do** Assignment Sheet 3, "Locate Receptacle Outlets in a Bathroom."

☐ 10. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 11. If the evaluation is not satisfactory, repeat Steps 4 and 9.

Learning Activities Sheet

☐ 11. **Check** With instructor for any additional assignments to be completed.

☐ 12. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 13. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

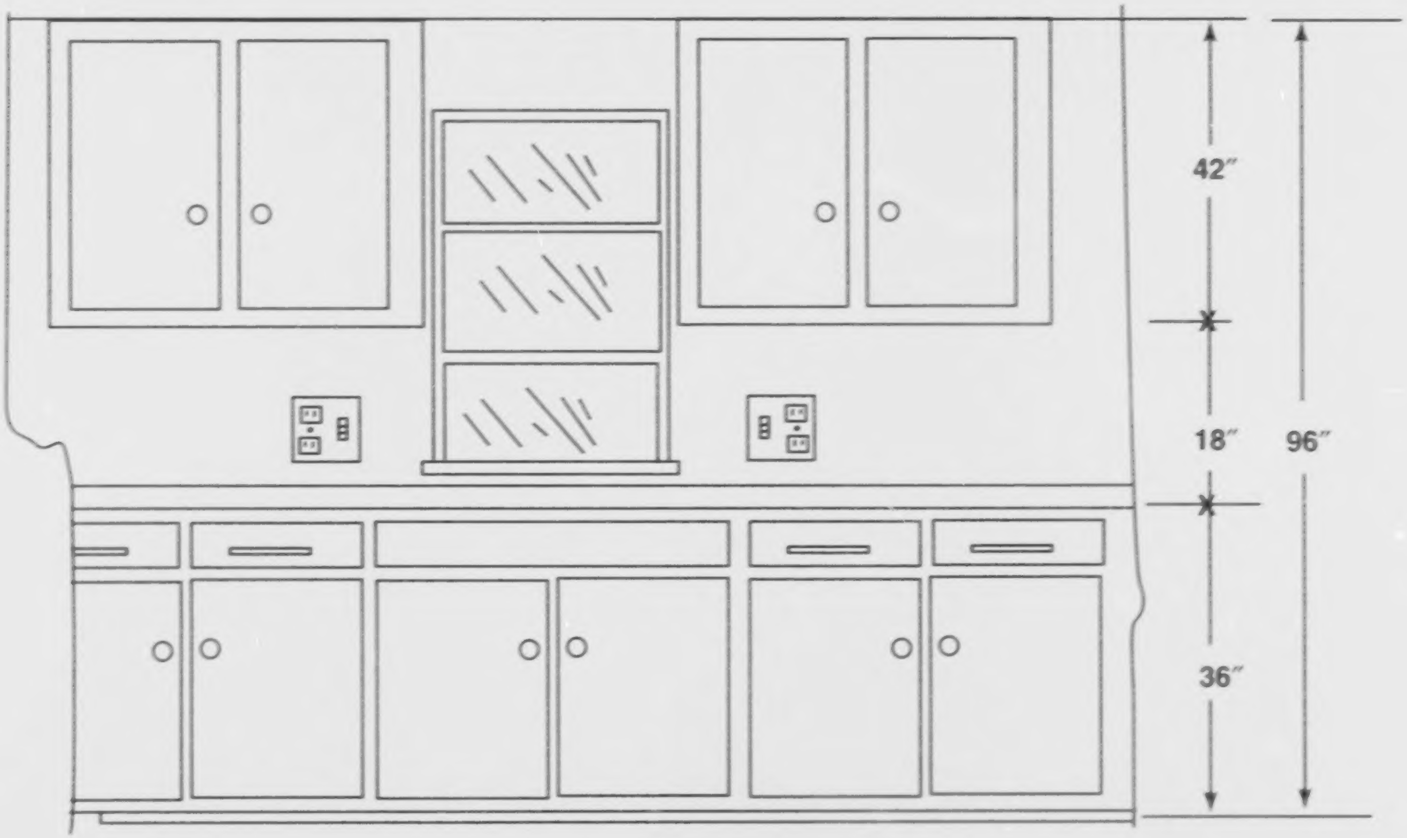
Teacher Supplement 1—Systems That Must Be Installed in a Residence Prior to Installing the Wall Finish

This supplement is intended to be used in conjunction with the Focus Assignment.

1. Intercom
2. Entertainment
3. Fire/Smoke/CO2 Alarms
4. Security
5. Plumbing
6. HVAC
7. Insulation
8. Central Vacuum
9. Gas
10. CATV
11. Telephone
12. Other Home Automation Wiring

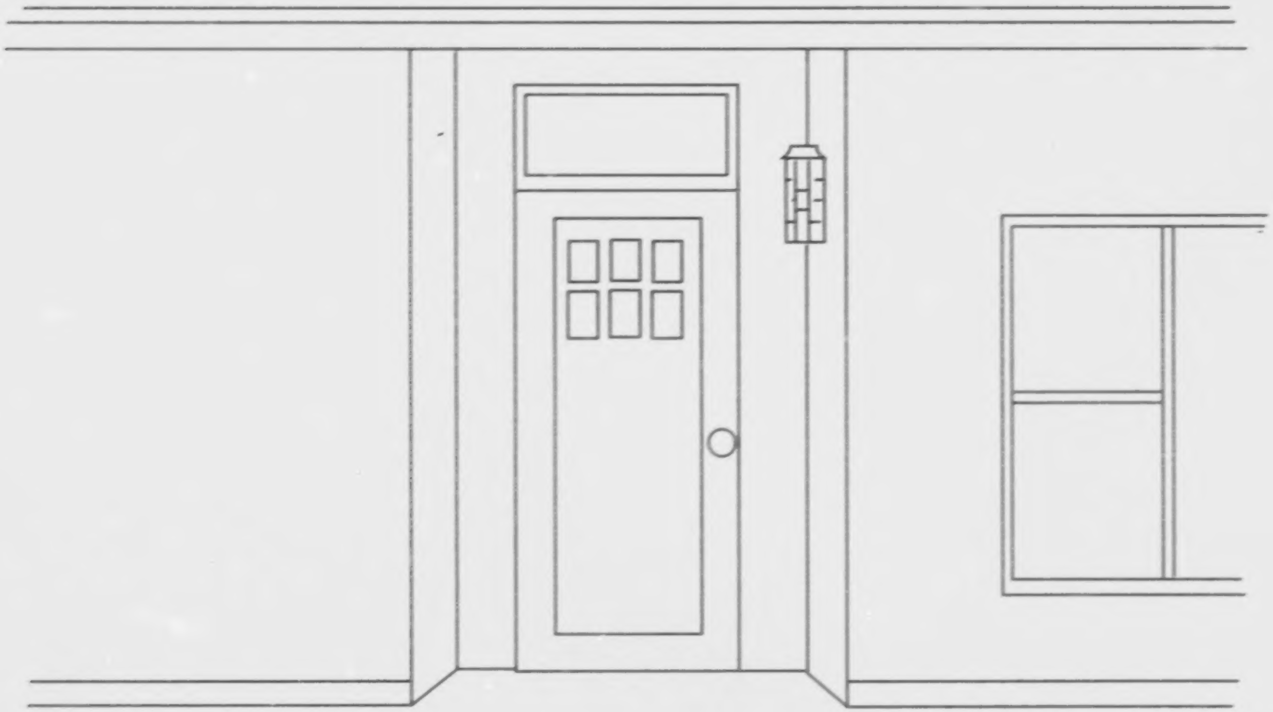
Note: Add systems that may be unique to your area.

Placement of Electrical Outlets in the Kitchen



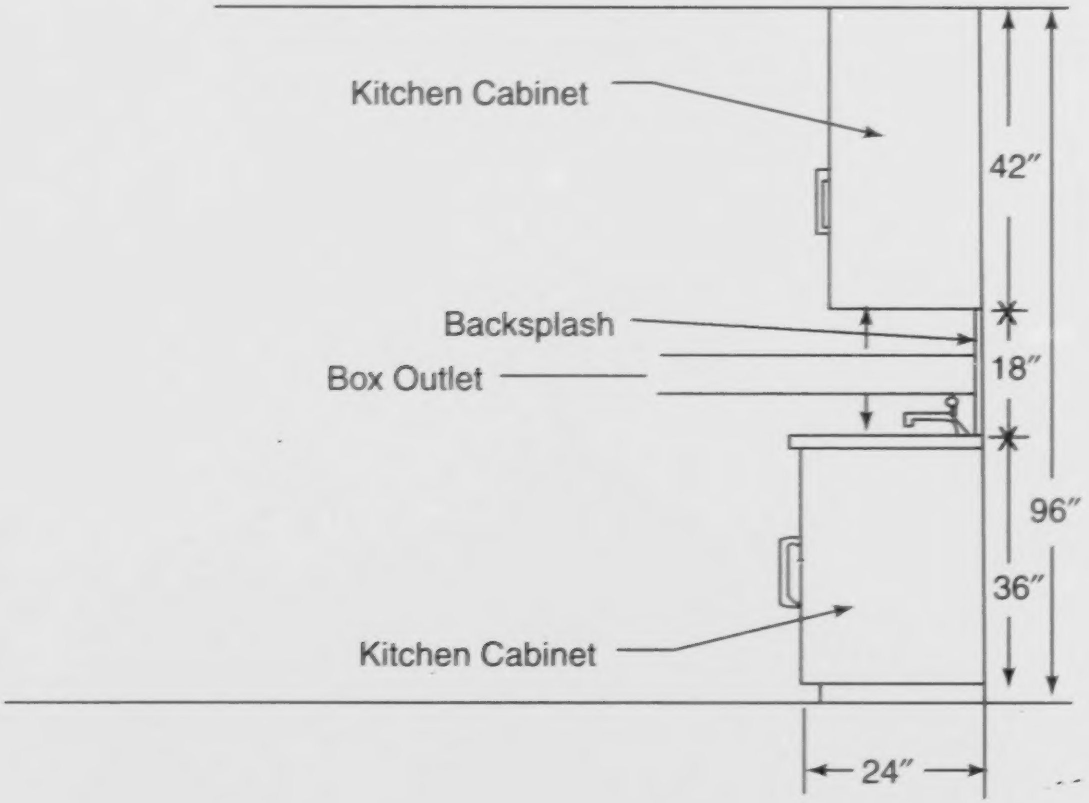
Putting Switches and Receptacle in Even Groups,
Makes the Job Look Planned

Box Locations (Outside Entrance and Exit)

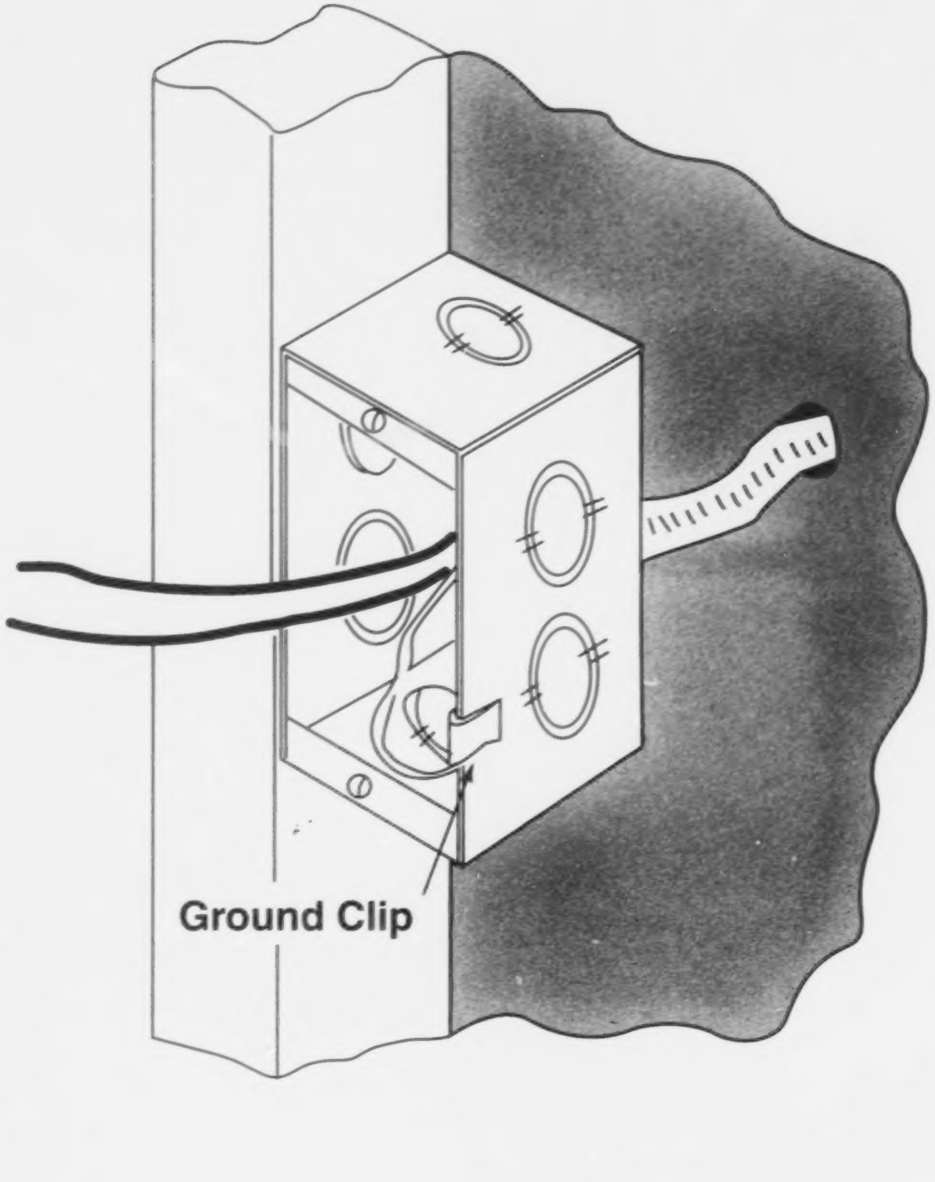


Keeping Boxes at Least Two Feet from the Top Plate
Will Allow Full View of the Larger Fixtures

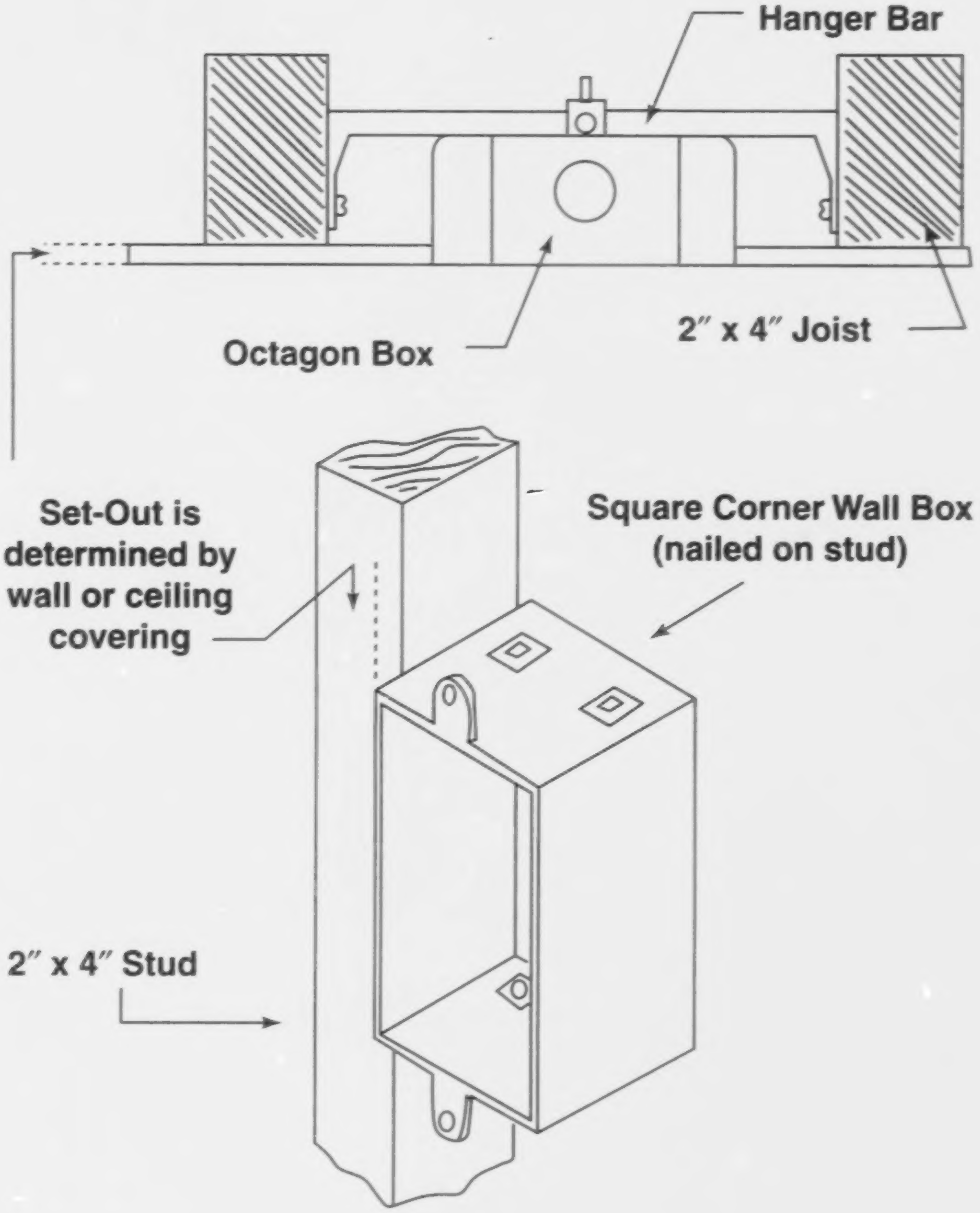
Examples of Kitchen Dimensions (For Placement of Boxes)


Kitchen Cabinet
42″
Backsplash
Box Outlet
18″
96″
36″
Kitchen Cabinet
24″

Flush Box Installation in Brick Veneer

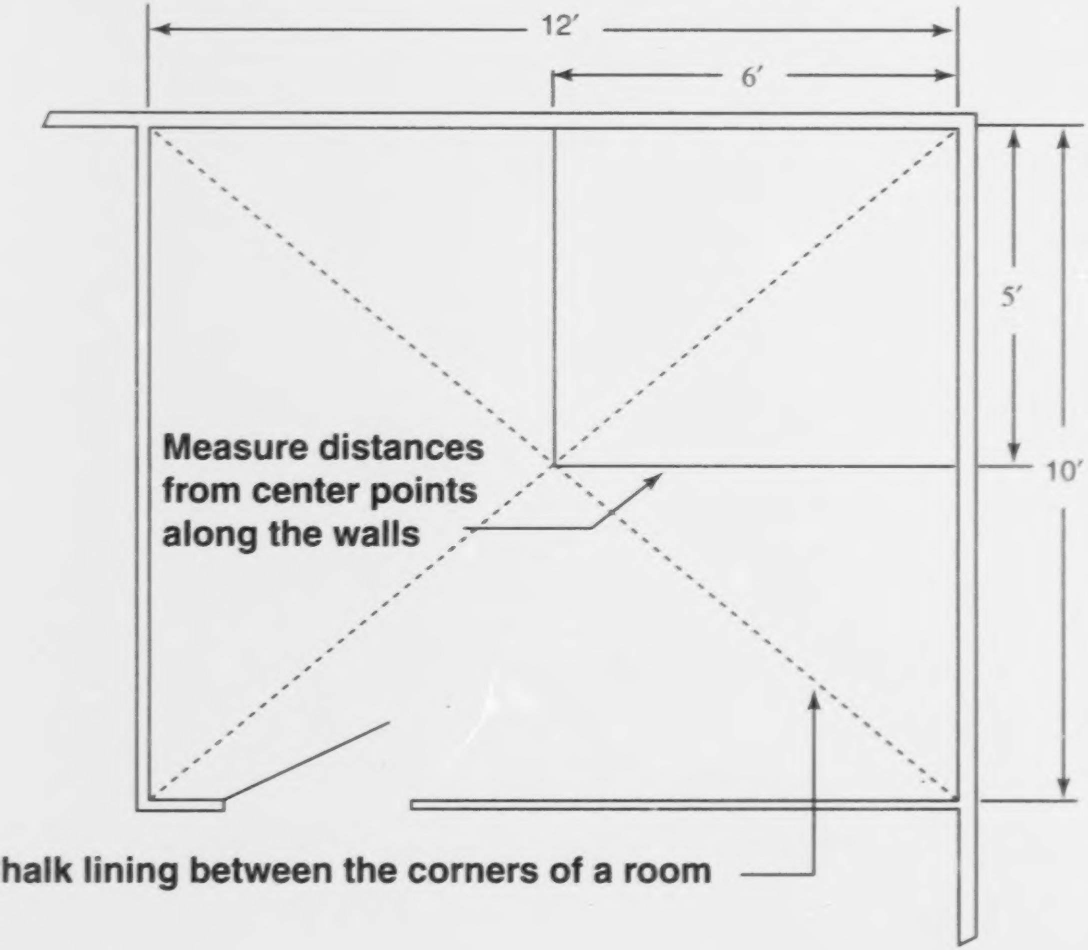

Ground Clip

Installing Boxes (Flush Mount)


Hanger Bar
Octagon Box
2″ x 4″ Joist
Set-Out is determined by wall or ceiling covering
Square Corner Wall Box (nailed on stud)
2″ x 4″ Stud

TM 5

Locating Center Points for Ceiling Outlet Boxes



Measure distances from center points along the walls

Chalk lining between the corners of a room

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 4–3

Answers to Assignment Sheet 4–7

Written Test 4–9

Answers to Written Test 4–17

Learning Activities Sheet 4–19

Transparency Masters

1—Parts of a Duplex Grounding Type Receptacle 4–23
2—Equipment Grounding Circuit 4–25

Student Components

Student Page

Objective Sheet 4–3

Information Sheet 4–5

Focus Assignment

List and Price Lighting Fixtures 4–19

Assignment Sheet

1—Troubleshoot Electrical Problems 4–21

Job Sheets

1—Wire a receptacle fed from a lighting outlet through a single pole switch 4–27
2—Wire a switch controlled split-wired receptacle 4–29
3—Wire a receptacle fed from a lighting outlet through a three-way switch 4–35
4—Wire a four-way switching situation with the supply entering the lighting outlet box 4–41
5—Mount a fan box according to manufacturer's recommendations . . . 4–47
6—Install a range or dryer receptacle 4–53
7—Connect a supply cord to a free standing range or dryer 4–57
8—Install a fixed appliance equipped with a pigtail to a branch circuit . . 4–59
9—Install a multi-circuit split-wired duplex grounding type receptacle . . 4–63
10—Install a fusible safety switch for an air-conditioning condenser . . . 4–67

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Parts of a Duplex Grounding Type Receptacle (Objective 8)
  TM 2—Equipment Grounding Circuit (Objective 9)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Design and construct a problem board that will facilitate set up and diagnosis of circuit malfunctions.
- Contact local electricians and invite them to class to show examples of troubleshooting techniques they employ. Also have them share some of their toughest troubleshooting problems and the outcomes. Have students take notes, then provide a question and answer session for students to ask questions concerning troubleshooting.
- Design and construct work boards for students to use in their performance of the job sheets included in this unit.
- Collect used appliances from equipment dealers or through private donations for use in completing job sheets in this unit.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas of improvement.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

Suggested Activities

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Gebert, Kenneth L. *Blueprint Reading*, 9th ed. Alsip, IL: American Technical Publishers, Inc., 1983.

- Gray, Elliot C., Jr. and Melbourne E. Bailey. *Electrical Construction and Maintenance Techniques*. Englewood Cliffs, NJ: Prentice-Hall, 1986.

- Hunzicker Brothers Catalog. Oklahoma City, OK.

Suggested Activities

- Mullin, Ray C. *Electrical Wiring: Residential*, 11th ed. Albany, NY: Delmar Publishers Inc., 1993.
- *1993 National Electrical Code®*. Quincy, MA: National Fire Protection Association, 1992.
- Taylor, Mark. *Residential Wiring*. Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1988.
- *National Electrical Code, 1999*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- Croft, Terrell, ed. *American Electrician's Handbook*, 13th ed. New York: McGraw-Hill, 1996.
- Holzman, Harvey N. *Modern Residential Wiring*. Goodheart-Willcox, 1999.
- Mullin, Ray C. *Electrical Wiring: Residential*, 13 ed. Albany, NY: Delmar Publishers, Inc., 1998.
- Locke Supply Catalog. Oklahoma City, OK.

Electronic Media

- Residential Wiring Series

  This is a 4-part series. Two of the titles are recommended for this unit.

  - Installing Outlets (21 minutes)
  - Installing Switched Circuits (24 minutes)

  Note: Titles are available in VHS or CD ROM format. Order from Bergwall Production Inc., 8 Ponds Edge Drive, Chadds Ford, PA., 19317-0804, call 800-645-3565, or visit www.bergwall.com.

Answers to Assignment Sheets

Assignment Sheet 1

Troubleshoot Electrical Problems

The troubleshooting steps should align with the steps listed in Objective 11 of the Information Sheet, but there may be variations due to the specific scenarios.

Listed below are possible solutions to the scenarios in Assignment Sheet 1. There may be other solutions to consider.

Scenario 1: The symptoms of blinking lights and clocks that need to be reset could indicate a loose connection in the service (whole house problem, not just 1 or 2 branch circuits). The "strange smell" at the breaker box could be caused by burning/charred insulation on the service conductors, due to a loose connection.

Visual inspection of the breaker box may reveal discolored service conductors or terminal lugs, bubbled or charred insulation, or oxidized conductors. If a loose connection is located in the panel, replace all damaged wires and lugs. You may need to check the meter socket, service disconnect, or further up the service loop.

Scenario 2: This could be due to many years of service causing stress on the receptacle device (i.e., they may always plug the vacuum into the same receptacle). In a typical "feed through" branch circuit, if one device fails, nothing down-stream of that receptacle will work. The defective device must be located and replaced.

Written Test

Name ____

Date ________________________________ Score __________

Objective 1

Match the terms related to trim out and troubleshooting with their definitions. Write the correct numbers in the blanks. Definitions continue on the next page.

1. Appliance
2. Troubleshooting
3. Terminal
4. Switch leg
5. Disconnecting means
6. Duplex grounding receptacle
7. Feed through
8. Traveler
9. Multiple receptacle
10. Strap or yoke
11. Switch loop
12. Split-wired receptacle
13. Pigtail
14. Receptacle connecting fin
15. Poles
16. Line leg
17. Switch
18. Device
19. Single receptacle
20. Cable clamp
21. Individual branch circuit
22. Trim out
23. Appliance (small) branch circuit
24. Volt ampere
25. Wires
26. Appliance-cord and plug connected
27. Appliance-fastened in place

_____ a. Conductor that carries electrical energy from the switch to the load

_____ b. The use of a box for splicing or rerouting conductors to get to another location

_____ c. Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, or deep frying

_____ d. A single yoke device with two or more receptacles

_____ e. The systematic diagnosis of a malfunction

_____ f. Conductors between light and switch when supply enters the light

_____ g. A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

_____ h. Point of attachment for conductors

_____ i. Metal strip containing one or more devices

_____ j. A single yoke device with two grounding type receptacles

_____ k. Transfer conductors in a switching situation; they are used between 3-ways and 4-ways

_____ l. Receptacle that has had a connecting fin removed for remote control or separate circuit connections

_____ m. Voltage multiplied times amperage

_____ n. Unit of an electrical system which is intended to carry but not utilize electrical energy

_____ o. Detachable design feature that makes terminals common connections

_____ p. Conductor that supplies electrical energy to a switch

_____ q. Current carrying conductors, both grounded and ungrounded, on a receptacle switch or overcurrent device

_____ r. Branch circuit that supplies only one piece of utilization equipment

_____ s. A 120V branch circuit rated at 1500 VA (20 amps) supplying energy to one or more outlets to which appliances are to be connected

_____ t. Permanently mounted in place and usually hard wired

_____ u. Splicing technique that leaves an accessible conductor for termination at a device, load, or grounding terminal

_____ v. Device used to open or transfer circuit direction

_____ w. Piece of equipment used to secure cables

_____ x. Final stage in a residential wiring project; involves devices and plates, connecting and securing equipment, hanging fixture, and testing the system

_____ y. Current carrying conductors and grounding conductors

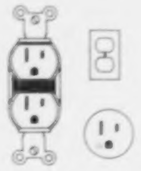
_____ z. A single contact device with no other contact device on the same yoke

_____ aa. Portable, and in some cases, stationary appliances permitted to be connected by a flexible cord

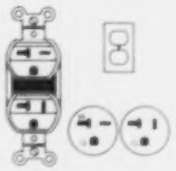
Written Test

Objective 2

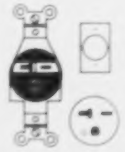
Identify common residential receptacle types and cover plates shown below. Write your answers in the blanks provided.



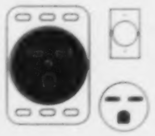
a. ____________________



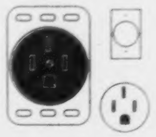
b. ____________________



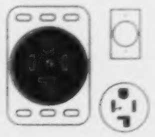
c. ____________________



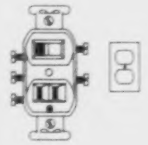
d. ____________________



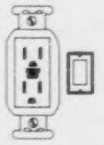
e. ____________________



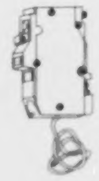
f. ____________________



g. ____________________



h. ____________________

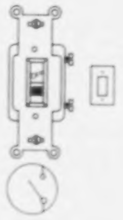


i. ____________________

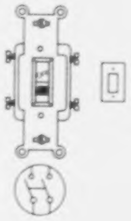
Written Test

Objective 3

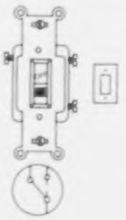
Identify common residential switch types and cover plates shown below. Write your answers in the blanks provided.



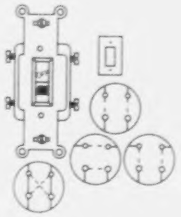
a. ____________________



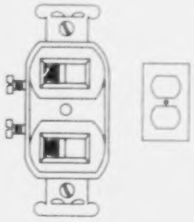
b. ____________________



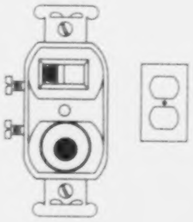
c. ____________________



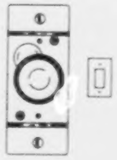
d. ____________________



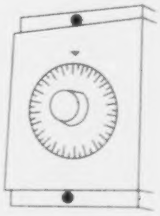
e. ____________________



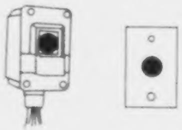
f. ____________________



g. ____________________



h. ____________________

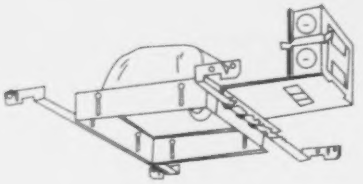


i. ____________________

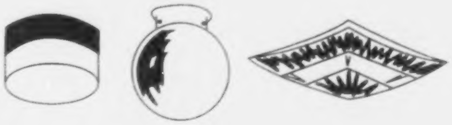
Objective 4

Match common residential fixture locations below with the correct types.

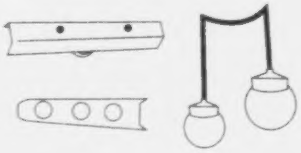
1. Dining room
2. Bedroom or hall
3. Recessed fixtures and trims
4. Bathroom
5. Closet
6. Outdoor entry



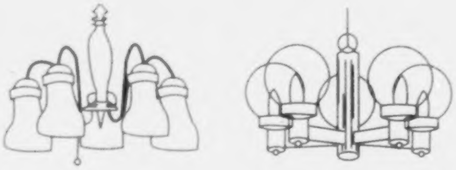
____ a.



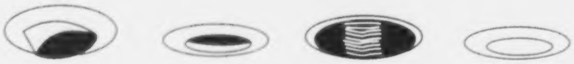
____ b.



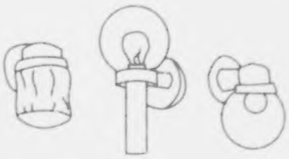
____ c.



____ d.



____ e.



____ f.

Written Test

Objective 5

Match appliance classifications below with their correct definitions. Write the correct numbers in the blanks.

1. Cord-and-plug connected
2. Fixed
3. Located on a separate circuit
4. Portable
5. Stationary

_____ a. A current consuming device which is permanently installed such as water heaters, built-in cook-tops or ovens, and electric furnaces.

_____ b. A current consuming device not permanently attached but, not ordinarily moved such as clothes dryers, washing machines, and free standing ranges.

_____ c. A current consuming device which is commonly moved such as blenders, mixers, toasters, and radios.

_____ d. A branch circuit that supplies only one (1) utilization equipment such as a range, dryer, or washing machine.

_____ e. Connected to a branch circuit with a pigtail plug inserted into a receptacle such as portable appliances, but may include stationary or fixed-in-place appliances.

Objective 6

Distinguish between requirements for appliance disconnect means by placing an "X" for permanently connected appliances to the correct requirement.

_____ a. An accessible plug and receptacle shall be permitted to serve as the disconnect means.

_____ b. The branch circuit breaker shall be permitted to serve as the disconnecting means where readily accessible to the user of the appliance.

Objective 7

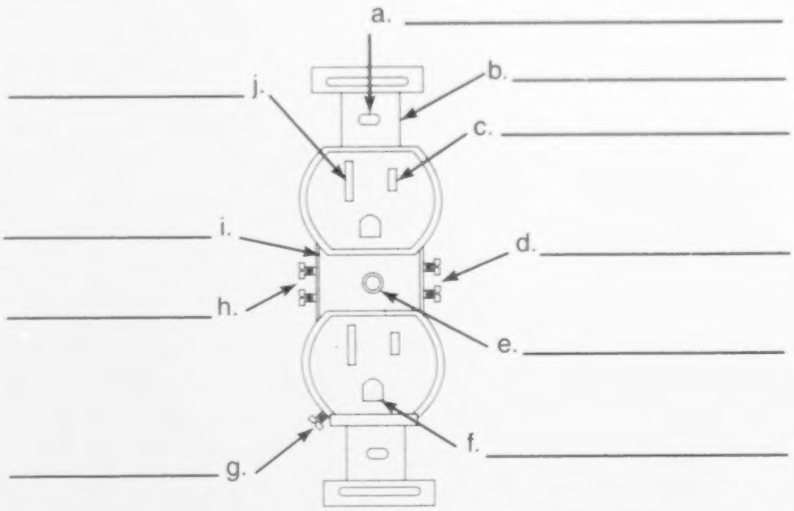
State the grounding requirement for appliances.

____

____

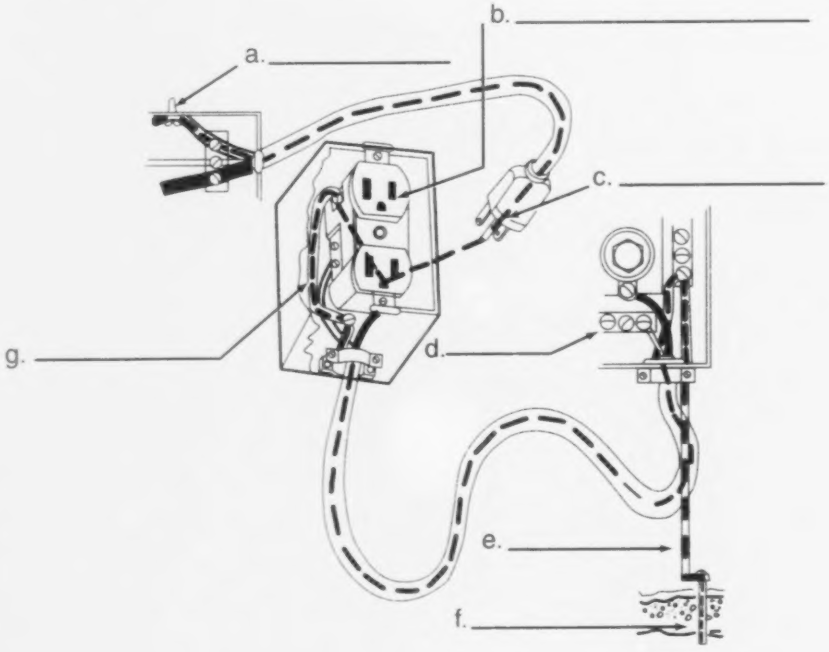
Objective 8

Identify the parts of a duplex grounding type receptacle. Write your answers in the blanks provided.



Objective 9

Identify the parts of an equipment grounding system. Write your answers in the blanks provided.



Written Test

Objective 10

Arrange in order the following steps for panel trim out by placing a "1" for the first step, a "2" for the second step and so on in the blanks preceding the steps.

_____ a. Connect ungrounded conductors to their overcurrent protection devices.

_____ b. Label panel in the form of a directory.

_____ c. Connect the grounding conductors to their panel location.

_____ d. Energize the system with temporary power.

_____ e. Connect grounded conductors to the panel neutral bar.

Objective 11

Select true statements concerning troubleshooting procedures by placing an "X" in the blanks preceding the true statements.

_____ a. Consulting the owner about the operation of a system may help to determine symptoms of a problem causing system.

_____ b. Locate the problem solving area by turning on the power and waiting for smoke to indicate where the problem is.

_____ c. Check the conductor to see if it is discolored from overheating or if the insulation is damaged or nicked.

_____ d. Replace fuse or circuit breaker with a larger size to eliminate breaker trip.

_____ e. Check devices and fixtures for worn or overheated parts.

_____ f. Repair or replace cause of problem.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 4
b. 7
c. 1
d. 9
e. 2
f. 11
g. 5
h. 3
i. 10
j. 6
k. 8
l. 12
m. 24
n. 18
o. 14
p. 16
q. 15
r. 21
s. 23
t. 27
u. 13
v. 17
w. 20
x. 22
y. 25
z. 19
aa. 26

Objective 2

a. Duplex grounding receptacle
b. Dual voltage receptacle
c. Air conditioner receptacle, 20 amp
d. Air conditioner receptacle, 30 amp
e. Range receptacle
f. Dryer receptacle
g. Switch and receptacle
h. Ground fault receptacle
i. Ground fault circuit breaker

Objective 3

a. Single pole
b. Double pole
c. Three way
d. Four way
e. Duplex switch
f. Switch and pilot light
g. Dimmer
h. Timer switch
i. Photo cell

Objective 4

a. 5
b. 2
c. 4
d. 1
e. 3
f. 6

Objective 5

a. 2
b. 5
c. 4
d. 3
e. 1

Objective 6

b

Objective 7

Appliances with exposed noncurrent carrying metal parts likely to become energized shall be grounded

Answers to Written Test

Objective 8

a. Mounting hole
b. Mounting bracket
c. Live slot
d. Live terminals
e. Cover mounting screw
f. Ground slot
g. Grounding terminal
h. Neutral terminals
i. Bridge
j. Neutral slot

Objective 9

a. Grounding connection at frame
b. Receptacle grounding slot
c. Attachment cap grounding prong
d. Neutral block
e. Grounding electrode conductor
f. Grounding electrode
g. Grounding conductor

Objective 10

a. 3
b. 4
c. 1
d. 5
e. 2

Objective 11

a, c, e, f

Prerequisites:
None

Learning Activities Sheet

Student Name ______________________________

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "List and Price Lighting Fixtures."

☐ 4. **Study** Information Sheet, Objectives 1 through 4.

☐ 5. **View** Videotapes entitled: "Installing Outlets" and "Installing Switched Circuits.".

☐ 6. **Do** Job Sheet 1, "Wire a Receptacle Fed From a Lighting Outlet Through a Single Pole Switch."

☐ 7. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 6.

☐ 8. **Do** Job Sheet 2, "Wire a Switch Controlled Split-Wired Receptacle."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 8.

☐ 10. **Do** Job Sheet 3, "Wire a Receptacle Fed From a Lighting Outlet Through a Three-Way Switch."

☐ 11. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 12. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 3 and repeat Step 10.

Learning Activities Sheet

☐ 12. **Do** Job Sheet 4, "Wire a Four-Way Switching Situation with the Supply Entering the Lighting Outlet Box."

☐ 13. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 14. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 4 and repeat Step 12.

☐ 14. **Do** Job Sheet 5, "Mount a Fan Box According to Manufacturer's Recommendations."

☐ 15. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 16. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 5 and repeat Step 14.

☐ 16. **Study** Information Sheet, Objectives 5 through 10.

☐ 17. **Do** Job Sheet 6, "Install a Range or Dryer Receptacle."

☐ 18. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 19. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 6 and repeat Step 17.

☐ 19. **Do** Job Sheet 7, "Connect a Supply Cord to a Free Standing Range or Dryer."

☐ 20. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 21. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 7 and repeat Step 19.

☐ 21. **Do** Job Sheet 8, "Install a Fixed Appliance Equipped with a Pigtail to a Branch Circuit."

☐ 22. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 23. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 8 and repeat Step 21.

☐ 23. **Do** Job Sheet 9, "Install a Multi-Circuit Split-Wired Duplex Grounding Type Receptacle."

☐ 24. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 25. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 9 and repeat Step 23.

☐ 25. **Do** Job Sheet 10, "Install a Fusible Safety Switch For an Air-Conditioning Condenser."

☐ 26. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to Step 27. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 10 and repeat Step 25.

☐ 27. **Study** Information Sheet, Objective 11.

☐ 28. **Do** Assignment Sheet 1, "Troubleshoot Electrical Problems."

☐ 29. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 30. If the evaluation is not satisfactory, repeat Steps 27 and 28.

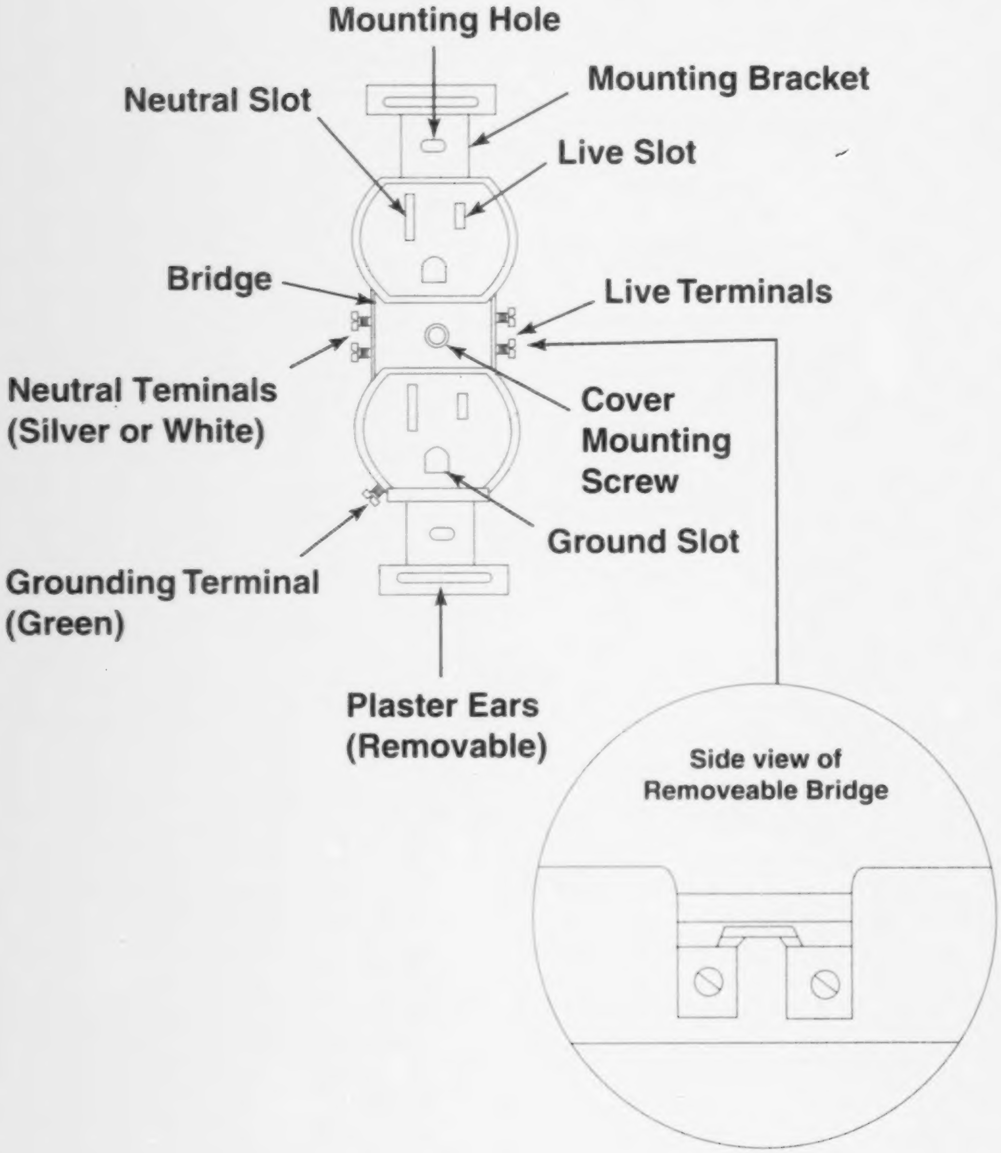
☐ 30. **Check** With instructor for any additional assignments to be completed.

☐ 31. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

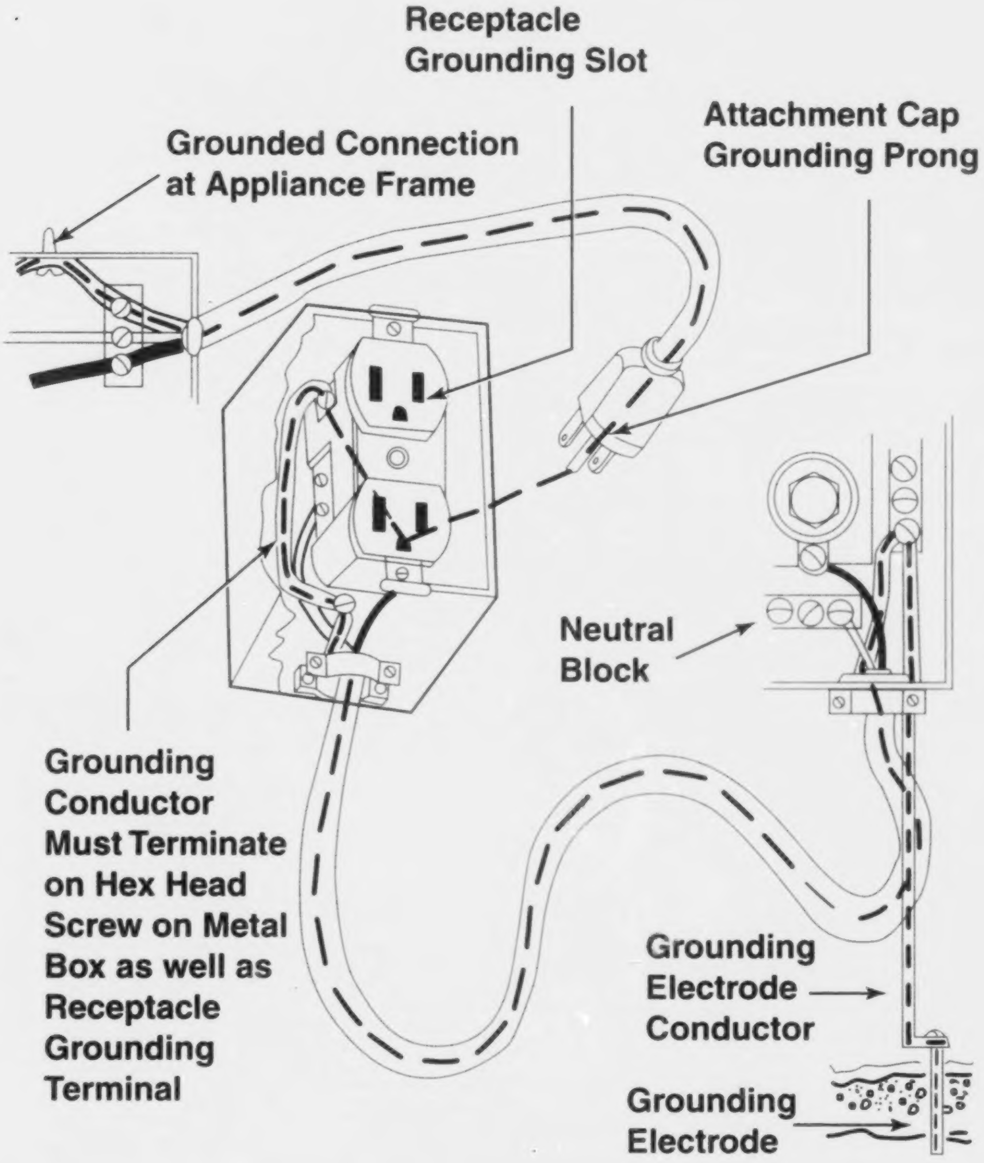
☐ 32. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

Parts of a Duplex Grounding Type Receptacle


Mounting Hole
Mounting Bracket
Neutral Slot
Live Slot
Bridge
Live Terminals
Neutral Teminals (Silver or White)
Cover Mounting Screw
Ground Slot
Grounding Terminal (Green)
Plaster Ears (Removable)
Side view of Removeable Bridge

Equipment Grounding Circuit


Receptacle Grounding Slot
Attachment Cap Grounding Prong
Grounded Connection at Appliance Frame
Neutral Block
Grounding Conductor Must Terminate on Hex Head Screw on Metal Box as well as Receptacle Grounding Terminal
Grounding Electrode Conductor
Grounding Electrode

TM 2

Unit 5

Low Voltage Wiring

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 5–3

Answers to Assignment Sheets 5–7

Written Test 5–9

Answers to Written Test 5–17

Learning Activities Sheet 5–21

Transparency Masters

1—Low Voltage Off/On Switching Cycle 5–23
2—Front and Rear Door Bell Circuit 5–25
3—Thermostat: Manual Fan Control 5–27
4—Thermostat: Cooling Circuit with Automatic Fan Control 5–29
5—Thermostat: Heating Circuit with Automatic Fan Control 5–31
6—Smoke Detector: Interconnect Wiring Diagram 5–33

Student Components

Student Page

Objective Sheet 5–3

Information Sheet 5–5

Focus Assignment

List Licensing Requirements for Low Voltage Wiring Systems 5–23

Assignment Sheets

1—List Uses of Low Voltage Cable 5–25
2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors 5–27

Job Sheets

1—Wire a Two-Button Chime Circuit 5–29
2—Wire Two Interconnecting Telephone Wall Jacks 5–35
3—Wire Two Interconnecting Smoke Detectors 5–39

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Low Voltage Off/On Switching Cycle (Objective 4)
  TM 2 —Front and Rear Door Bell Circuit (Objective 5)
  TM 3—Thermostat: Manual Fan Control (Objective 6)
  TM 4—Thermostat: Cooling Circuit with Automatic Fan Control (Objective 7)
  TM 5—Thermostat: Heating Circuit with Automatic Fan Control (Objective 8)
  TM 6—Smoke Detector: Interconnect Wiring Diagram (Objective 11)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Suggested Activities

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Contact a local sales distributor to visit the class and demonstrate low voltage lighting and signaling devices.
- Assign students to write a report on the advantages and disadvantages of low voltage lighting. Discuss student reports in class.
- Contact a local telephone company representative to visit the class and demonstrate phone systems. Discuss local requirements for installation of the equipment and system.
- Contact a local C.A.T.V. (Community Antenna Television) cable system to visit the class and discuss the local requirements for installation of equipment and the connection to their system.
- Plan an outside field trip to local phone company and C.A.T.V. cable system switching locations.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

Suggested Activities

- Evaluate the assignment sheets. Rate the student using the criteria listed on each assignment sheet. See Answers to Assignment Sheets for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

  Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

  Sample A

  4—**Skilled**—Can perform job with no additional training.
  3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
  2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
  1—**Unskilled**—Is familiar with process, but is unable to perform job.
  0—**No exposure**—No information or practice provided during training program.

  Sample B

  Yes—Can perform job with no additional training.
  No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.

- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.

- Reteach and retest as required.

Suggested Activities

Resources Used in Developing This Unit

Print Media

- Foley, Joseph H. *Electrical Wiring Fundamentals*. New York: Gregg McGraw-Hill Book Company.
- Holzman, Harvey N. *Modern Residential Wiring*. South Holland, IL: Goodheart-Wilcox Company, Inc., 1986.
- Holzman, Harvey N. *Modern Residential Wiring*. South Holland, IL: Goodheart-Wilcox Company, Inc., 1996.
- Mullin, Ray C. *Electrical Wiring: Residential*, Eighth Edition. Albany, NY: Delmar Publishers, Inc., 1984.
- Mullin, Ray C. *Electrical Wiring: Residential*, 12th Edition. Albany, NY: Delmar Publishers, Inc., 1996.
- Taylor, Mark. *Residential Wiring*, Revised. Stillwater, OK: Mid-America Vocational Curriculum Consortium, 1983.

Suggested Supplemental Resources

Print Media

- Croft, Terrell, ed. *American Electrician's Handbook*, 13th ed. New York: McGraw-Hill, 1996.
- Hayes, Jim and Paul Rosenberg. *Data, Voice, and Video Cable Installation*. Albany, NY: Delmar Publishers, Inc. 1997.
- Kubala, Thomas S. *Electricity 1: Devices, Circuits, and Materials*, Sixth Edition. Albany, NY: Delmar Publishers, Inc., 1995.
- Catalog—Hunzicker Brothers Catalog, 501 N. Virginia, Oklahoma City, OK 73125.
- *NFPA 72, National Fire Alarm Code*. Quincy, MA: National Fire Protection Association, 1996.
- *TIA-570, Residential and Light Commercial Wiring Standard*, Telecommunications Industry Association.

Electronic Media

- Telecommunications Industry Association—www.tiaonline.org. Provides a forum for the examination of global industry issues and information. Develops standards used worldwide.
- Home Tech Solutions—www.hometech.com. Contains information on residential telecommunications wiring, standards, and all associated products.

Answers to Assignment Sheet

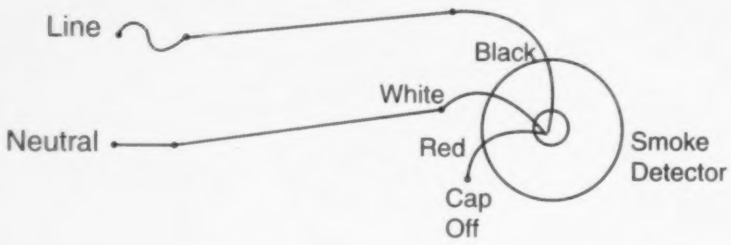
Assignment Sheet 1

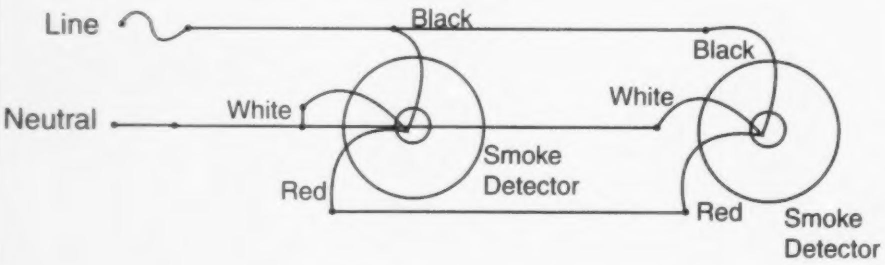
Draw a wiring diagram indicating the proper connection for bell circuit equipment

1. CL2P–Class 2 Plenum cable
2. CL2R—Class 2 Riser cable
3. CL2–Class 2 cable
4. CL2X–Class 2 cable, limited use
5. NPLFP–Non power-limited fire alarm circuit cable for use in environmental air spaces
6. NPLFR–Non power-limited fire alarm circuit cable for use as riser cable
7. NPLF–Non power-limited fire alarm circuit cable for general use
8. FPLP–Power limited fire alarm cable for plenums
9. FPLR–Power limited fire alarm cable for risers
10. FPL–Power limited fire alarm cable for general use
11. CMP–Communication general-purpose cable
12. CMR–Communication riser cable
13. CM–Communication cable for general use
14. CATVP–Community antenna television cable for plenumns
15. CATVR–Community antenna television cable for risers
16. CATV–Community antenna television cable for general use

Assignment Sheet 2

Draw a diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors


Line
Black
White
Neutral
Red
Smoke Detector
Cap Off


Line
Black
Black
White
White
Neutral
Smoke Detector
Red
Red
Smoke Detector

Written Test

Name ______________________________

Date ______________________ Score __________

Objective 1

Match the terms with their correct definitions. Write the correct numbers in the blanks.

1. Coaxial cable
2. Heat detector
3. Momentary contact switch
4. POTS
5. Pull-push solenoid
6. Relay
7. Remote control lighting system
8. Ring
9. Signaling circuit
10. Smoke detector
11. Solenoid
12. Telephone system
13. Thermostat
14. Tip
15. Transformer

_____ a. A device that senses temperature variations from a set point and, in turn, acts to control a circuit

_____ b. Electromagnetic device for remote or automatic control

_____ c. Electromagnetic cylinder that moves an iron plunger when current is applied

_____ d. Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has circuits applied to it

_____ e. A switch that is closed or opened only while the operator touches it

_____ f. An electrical device used to step up or step down a primary voltage to a desired secondary voltage

_____ g. A fire warning device commonly used in a residence; available in two types: photoelectric or ionization

_____ h. A personal communication system installed in the home to provide outside conversation with the world

_____ i. A fire warning device commonly used in a residence; available in two types: fixed or rate-of-rise temperature detectors

_____ j. Conductor used for carrying communication signals

_____ k. Old system of residential wiring using a quad wire conductor consisting of two pair of wire loosely twisted in a jacket

_____ l. Lighting system consisting of low voltage cable, low voltage relays, low voltage switches, and a transformer(s) than enable lighting circuits to be controlled by low voltage wiring circuits

_____ m. Telephone conductor that is connected to the negative terminal from the telephone company

_____ n. Any electric circuit that energizes signaling equipment

_____ o. Telephone conductor that is connected to the positive terminal from the telephone company

Objective 2

Select true statements concerning the requirements of low voltage lighting systems by placing an "X" in the blanks next to the true statements.

_____ a. Cannot be installed within 20′ of a pool, spa, fountain, or similar location unless permitted by *NEC* Article 680

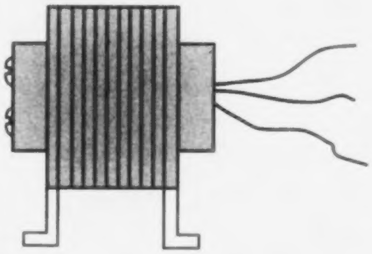
_____ b. Lighting systems shall be listed for low voltage purposes

_____ c. Cannot be installed where concealed in, or extended through a building wall

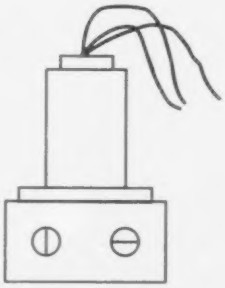
_____ d. Installed only on a 30 amp or less branch circuit

Objective 3

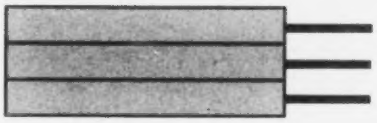
Identify the parts of a low voltage wiring system. Write your answers in the blanks provided.



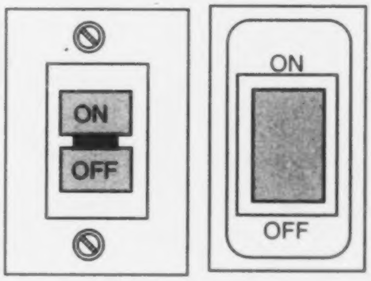
a. ______________________



b. ______________________



c. ______________________



d. ______________________

Objective 4

Describe the process that takes place during a low voltage lighting circuit off/on cycle.

"On" switch is pushed:

(1) ____

(2) ____

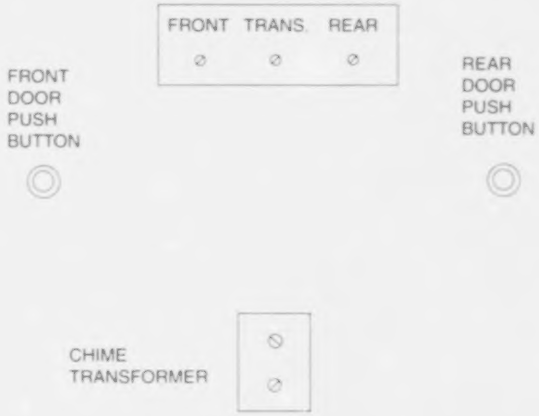
"Off" switch is pushed:

(1) ____

(2) ____

Objective 5

Complete the following drawing of a front and rear door bell circuit by making the proper connections.

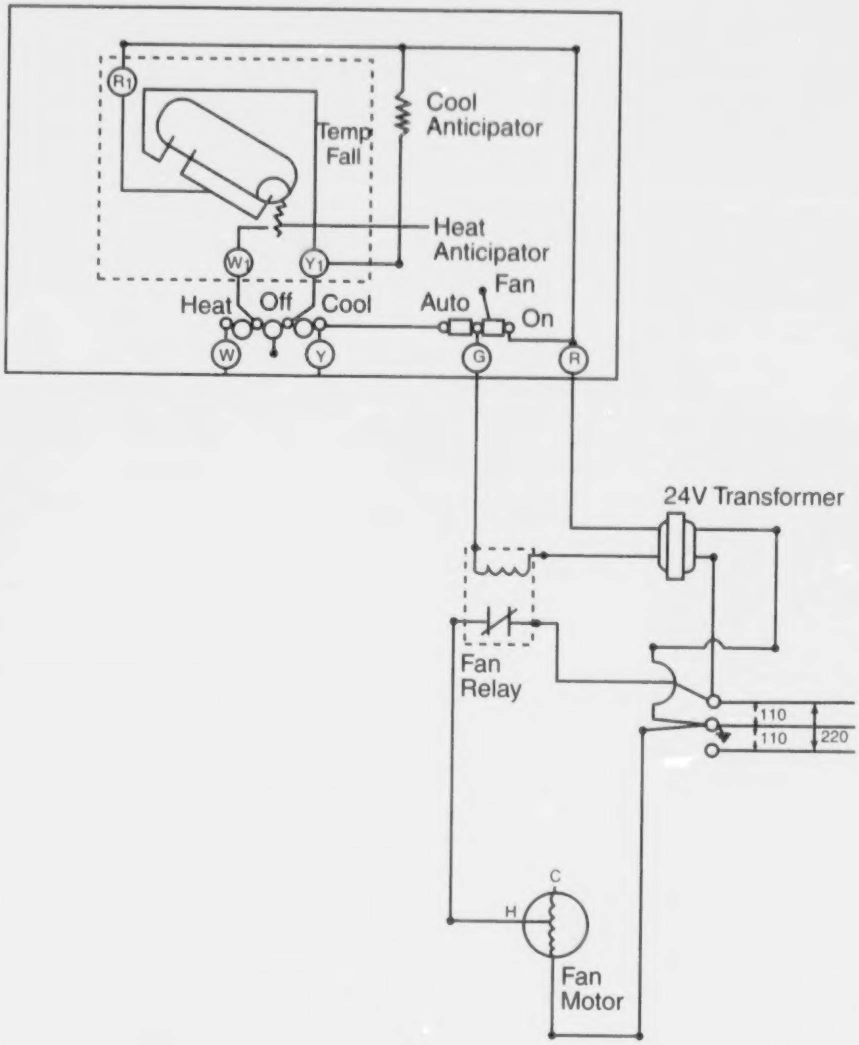

FRONT
TRANS.
REAR
FRONT DOOR PUSH BUTTON
REAR DOOR PUSH BUTTON
CHIME TRANSFORMER

Written Test

Objective 6

Complete a thermostat drawing of the manual fan switching circuit below to indicate the current flow path through the fan control switch and fan relay.

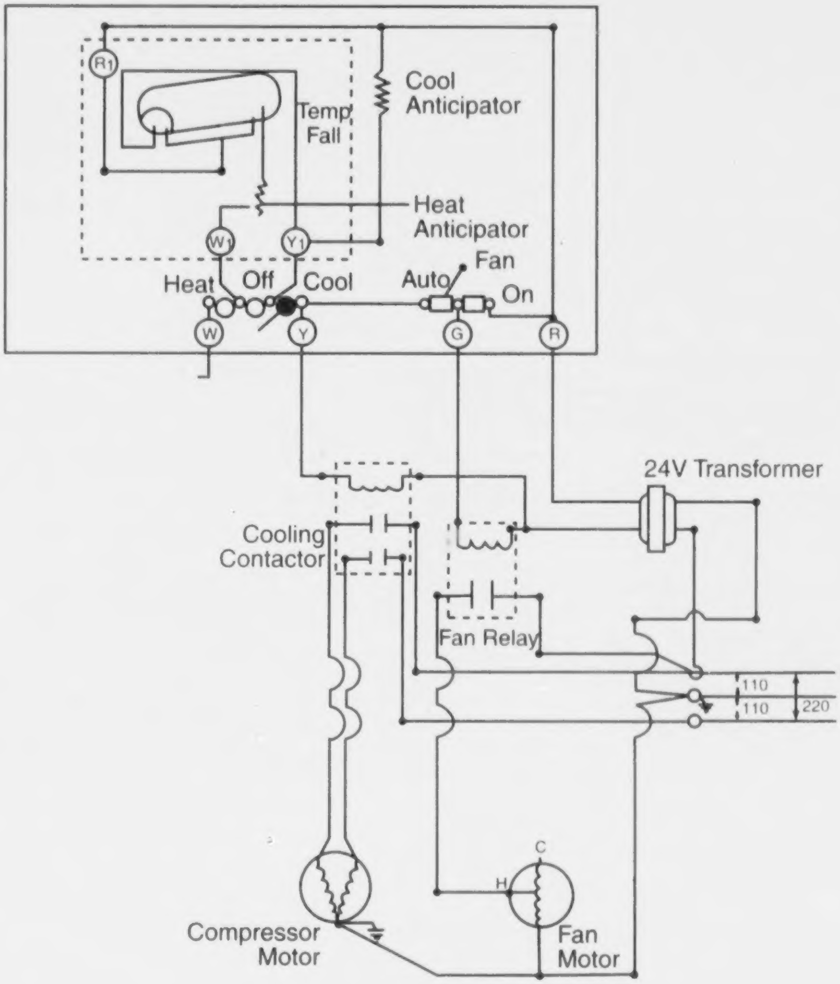
Note: Let → → → indicate current flow.


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

Objective 7

Complete the thermostat drawing below to indicate the current flow path with the thermostat system switch in the cool position and the fan switch on auto.

Note: Show both fan and cooling relays closed.

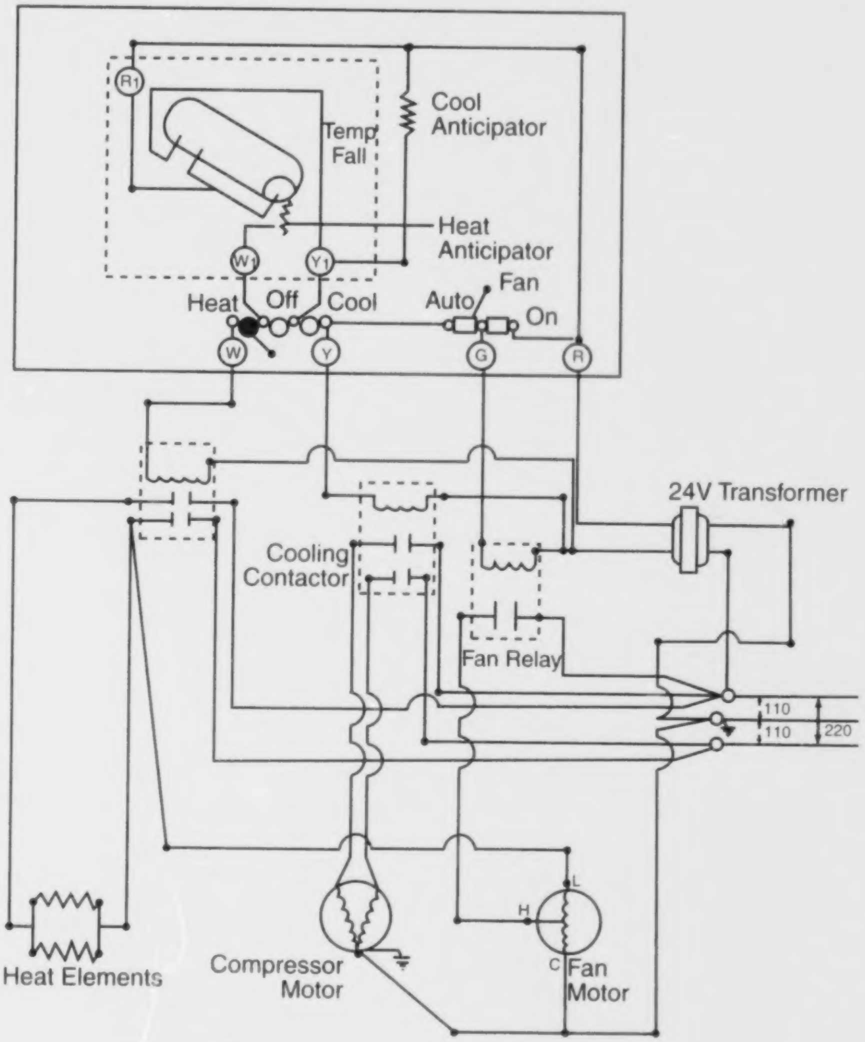

R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

Written Test

Objective 8

Complete the thermostat drawing below to indicate the current flow paths with the thermostat system switch in the heat position and the fan switch on auto.

Note: Show heat relay closed



R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Fan
Auto
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

Objective 9

Complete statements concerning anticipator circuits on low voltage thermostats. Write in the blanks the word(s) that best completes each statement.

a. Heat and cool anticipators are installed to compensate for ______________________.

b. Cool anticipator

   (1) It is wired ______________________ to mercury switch.

   (2) Heat causes bimetal to tilt bulb and ______________________ circuit before room temperature actually reaches "on" temperature setting.

c. Heat anticipator

   (1) It is wired ______________________ to mercury switch.

   (2) Heat causes bimetal to tilt bulb and ______________________ circuit before room temperature reaches desired room setting.

Objective 10

Select true statements concerning communication circuits by placing an "X" in the blanks next to the true statements.

_____ a. The point where the local telephone company's wiring ends and the home owner's interior wiring begins is called the demarcation point.

_____ b. Television cable systems need not be grounded.

_____ c. Most intercom systems incorporate radio and tape through the system speakers.

_____ d. The recommended telephone wiring for new construction is 2 pair, 4 conductor cable.

_____ e. The recommended wiring scheme for residential telephone wiring is the Star method.

_____ f. Intercom systems allow on-way monitoring or two-way conversation throughout the residence.

_____ g. Cable types for television systems are twin lead (150 ohm) and coaxial (70 ohm).

_____ h. Telephone conductors may share the same stud space as electrical branch circuit wiring.

Written Test

Objective 11

Complete statements concerning smoke and fire alarm systems. Write in the blanks the word(s) that best complete each statement.

a. Fire warning devices commonly used in a residence are a ____________________ and a ________________________ detector.

b. ________________________ detectors sense a specific fixed temperature a rate-of-rise.

c. The two most common types of smoke detectors are the __________________ type and the ________________________ type.

d. ________________________ is the third leading cause of accidental fatalities.

Objective 12

Select true statements concerning the operation of a garage door opener by placing an "X" in the blanks next to the true statements.

_____ a. The opener contains a motor, radar controller, motor reversing switch, keynote speaker, radio operated controller, and electric brake.

_____ b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers.

_____ c. The push-button or key operated station consists of a normally open momentary contact switch connected by 4-wire low voltage cable to the control unit. A photoelectric sensor system is also connected to the control unit by low voltage cable to insure a clear path for the door to travel.

_____ d. The radio-controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency, it will energize the motor in the opposite direction of its previous travel.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 13
b. 6
c. 11
d. 5
e. 3
f. 15
g. 10
h. 12
i. 2
j. 1
k. 4
l. 7
m. 8
n. 9
o. 14

Objective 2

b, c

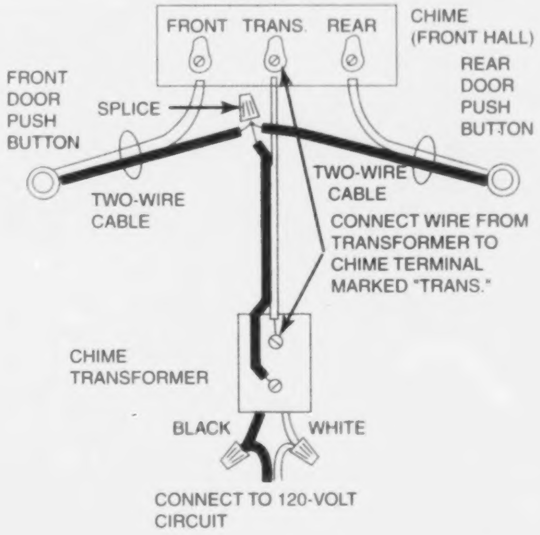
Objective 3

a. Transformer
b. Low voltage lighting relay
c. Low voltage cable
d. Remote control lighting switch

Objective 4

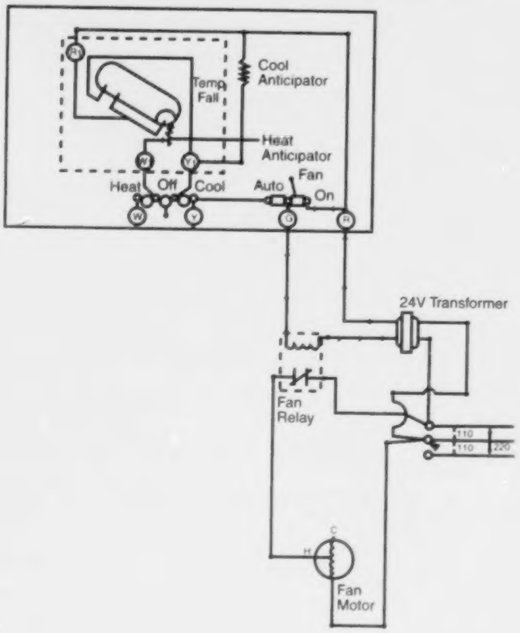
a. "On" switch is pushed
    (1) Circuit is completed to closing movement of solenoid in relay
    (2) Core is moved and circuit is completed
b. "Off" Switch is pushed
    (1) Circuit is completed to opening movement of solenoid in relay
    (2) Core is moved and circuit is opened

Objective 5

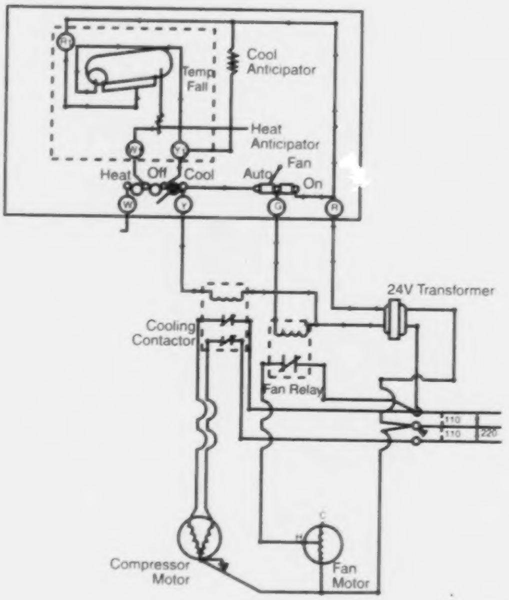

FRONT
TRANS.
REAR
CHIME (FRONT HALL)
FRONT DOOR PUSH BUTTON
SPLICE
REAR DOOR PUSH BUTTON
TWO-WIRE CABLE
TWO-WIRE CABLE
CONNECT WIRE FROM TRANSFORMER TO CHIME TERMINAL MARKED "TRANS."
CHIME TRANSFORMER
BLACK
WHITE
CONNECT TO 120-VOLT CIRCUIT

Answers to Written Test

Objective 6

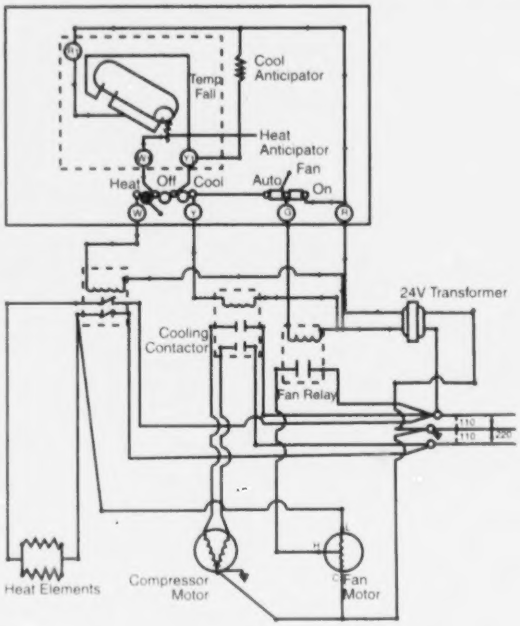

Cool Anticipator
Temp Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
24V Transformer
Fan Relay
110
110
220
Fan Motor

Objective 7


Cool Anticipator
Temp Fall
Heat Anticipator
Heat
Off
Cool
Auto
Fan
On
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
Compressor Motor
Fan Motor

Answers to Written Test

Objective 8



R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
Heat Elements
Compressor Motor
H
L
C
Fan Motor

Objective 9

- a. Bimetallic lag
- b. (1) Parallel
  - (2) Close
- c. (1) In series
  - (2) Open

Objective 10

a, c, e, f

Objective 11

- a. Heat, smoke
- b. Heat
- c. Photoelectric, ionization
- d. Fire

Objective 12

b, d

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Do** Focus Assignment, "List Licensing Requirements for Low Voltage Wiring Systems."

☐ 4. **Study** Information Sheet, Objectives 1 through 3.

☐ 5. **Do** Assignment Sheet 1, "List Uses of Low Voltage Cable."

☐ 6. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 7. If the evaluation is not satisfactory, repeat Steps 4 and 5.

☐ 7. **Study** Information Sheet, Objectives 4 and 5.

☐ 8. **Do** Job Sheet 1, "Wire a Two-Button Chime Circuit."

☐ 9. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 10. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat Step 8.

☐ 10. **Study** Information Sheet, Objectives 6 through 10.

☐ 11. **Do** Job Sheet 2, "Wire Two Interconnecting Telephone Wall Jacks."

☐ 12. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 13. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 11.

Learning Activities Sheet

☐ 13. **Study** Information Sheet, Objectives 11 and 12.

☐ 14. **Do** Assignment Sheet 2, "Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors."

☐ 15. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 16. If the evaluation is not satisfactory, repeat Steps 13 and 14.

☐ 16. **Do** Job Sheet 3, "Wire Two Interconnecting Smoke Detectors."

☐ 17. **Stop** Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 18. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat Step 16.

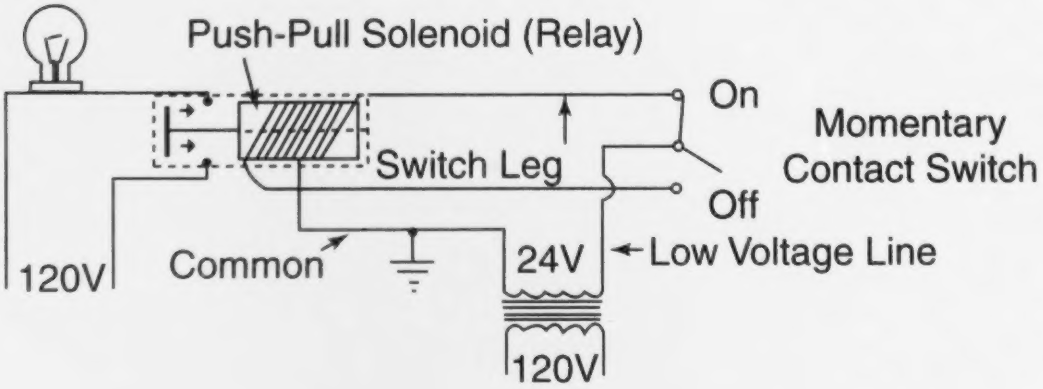
☐ 18. **Check** With instructor for any additional assignments to be completed.

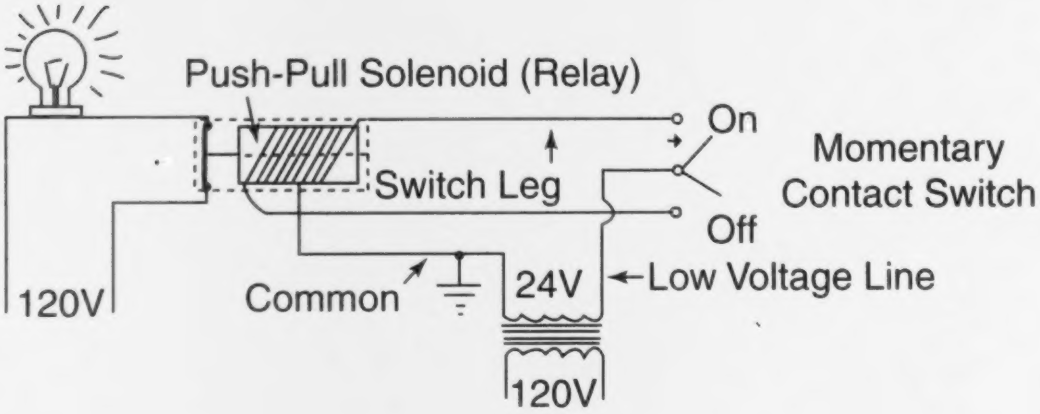
☐ 19. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

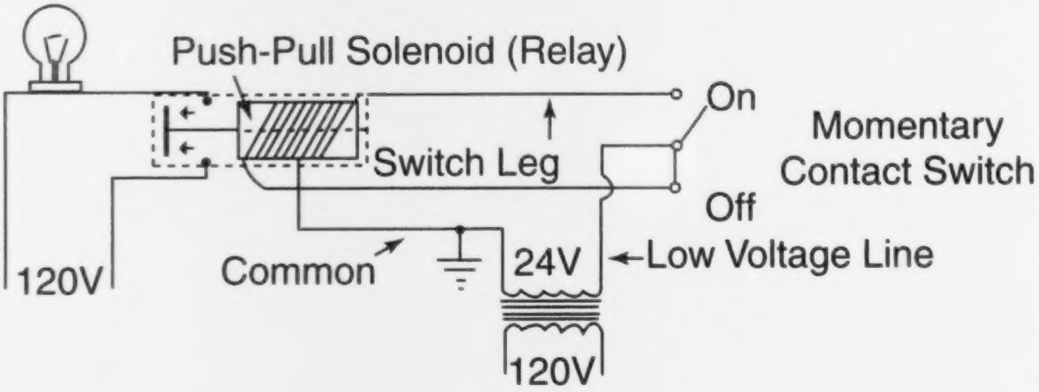
☐ 20. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

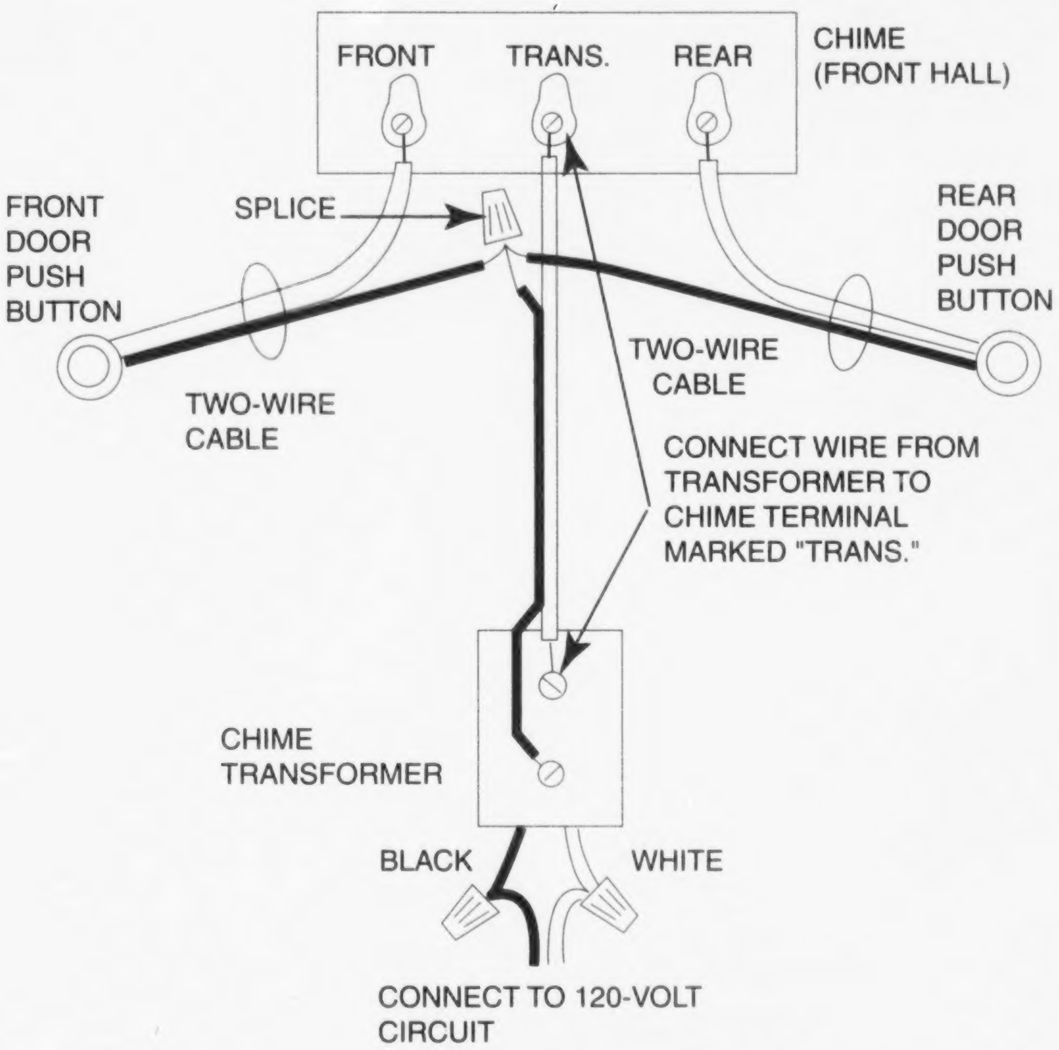
Low Voltage Off/On Switching Cycle


Push-Pull Solenoid (Relay)
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V


Push-Pull Solenoid (Relay)
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

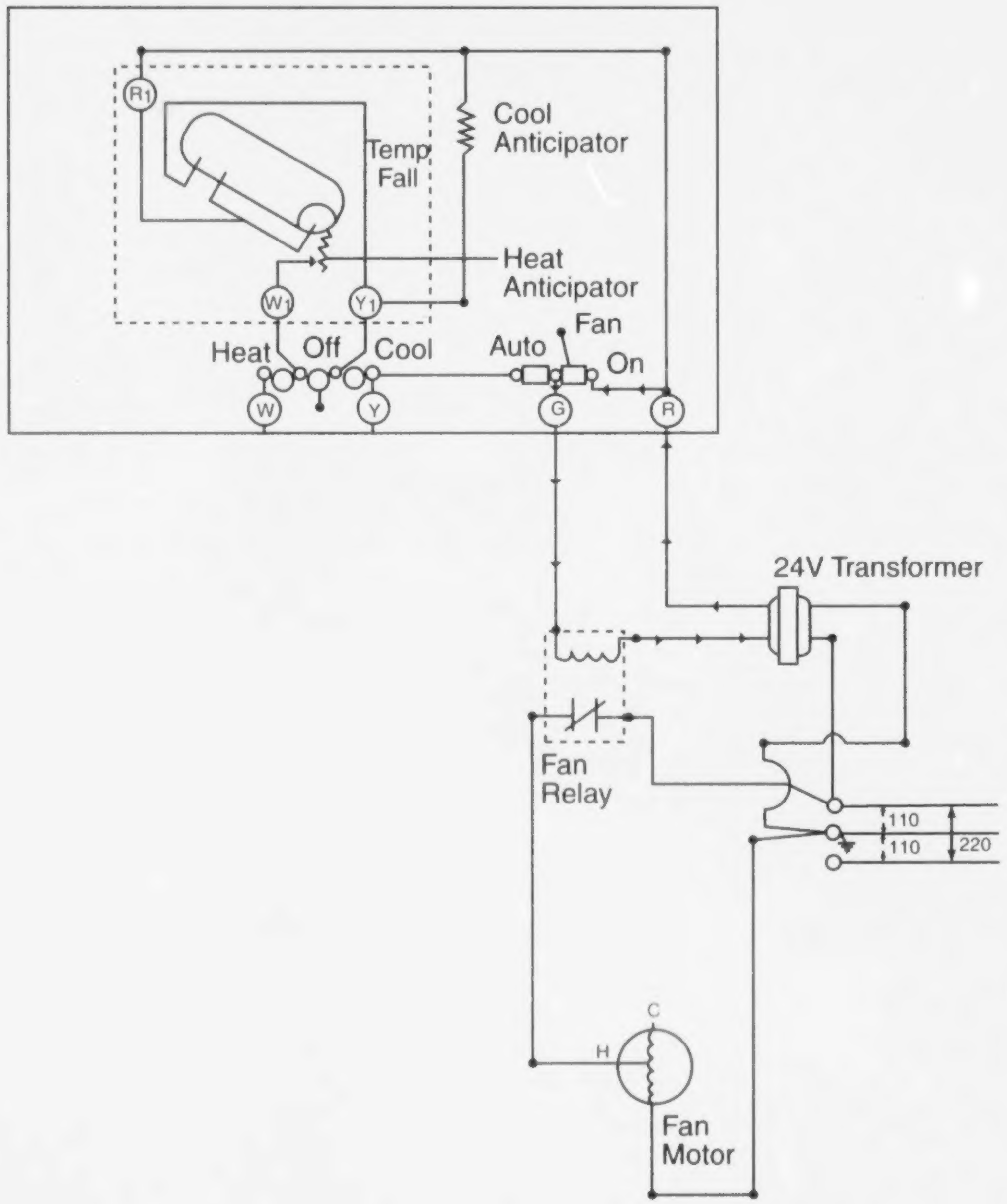

Push-Pull Solenoid (Relay)
On
Momentary
Contact Switch
Switch Leg
Off
Common
24V
Low Voltage Line
120V
120V

Front and Rear Door Bell Circuit


FRONT
TRANS.
REAR
CHIME (FRONT HALL)
FRONT DOOR PUSH BUTTON
SPLICE
REAR DOOR PUSH BUTTON
TWO-WIRE CABLE
TWO-WIRE CABLE
CONNECT WIRE FROM TRANSFORMER TO CHIME TERMINAL MARKED "TRANS."
CHIME TRANSFORMER
BLACK
WHITE
CONNECT TO 120-VOLT CIRCUIT

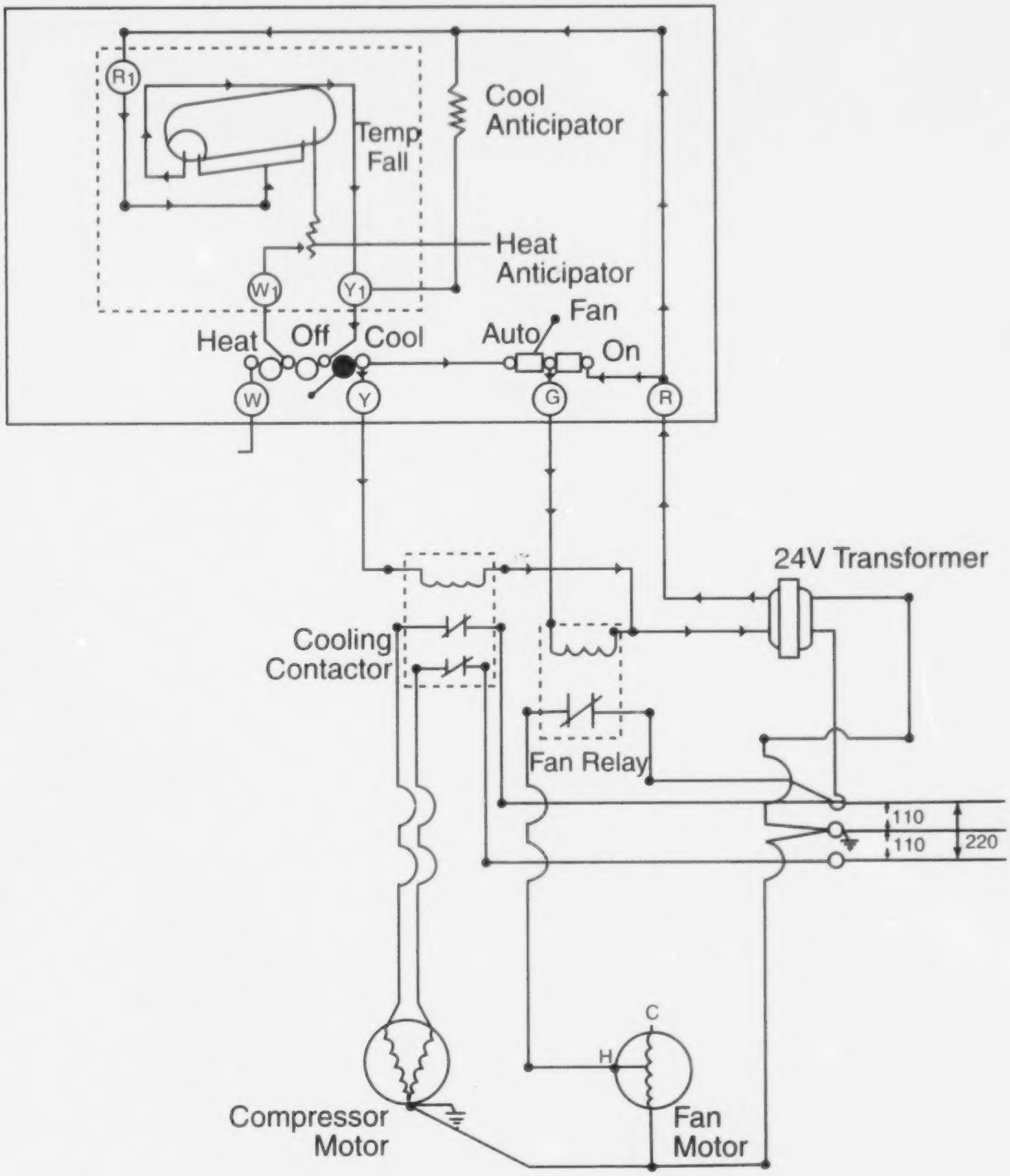
TM 2

Thermostat: Manual Fan Control


R1
Temp
Fall
Cool
Anticipator
Heat
Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan
Relay
110
110
220
C
H
Fan
Motor

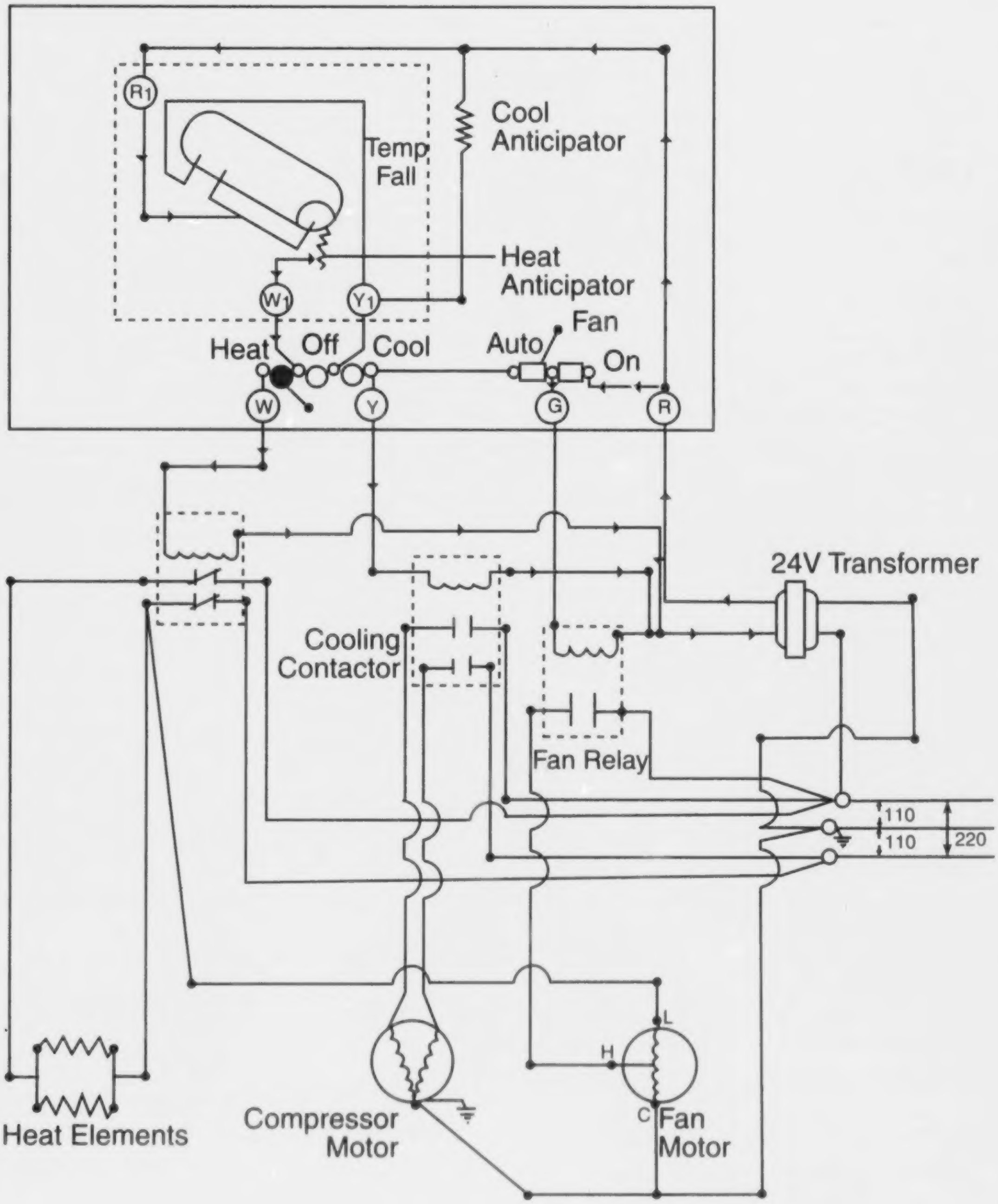
TM 3

Thermostat: Cooling Circuit with Automatic Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

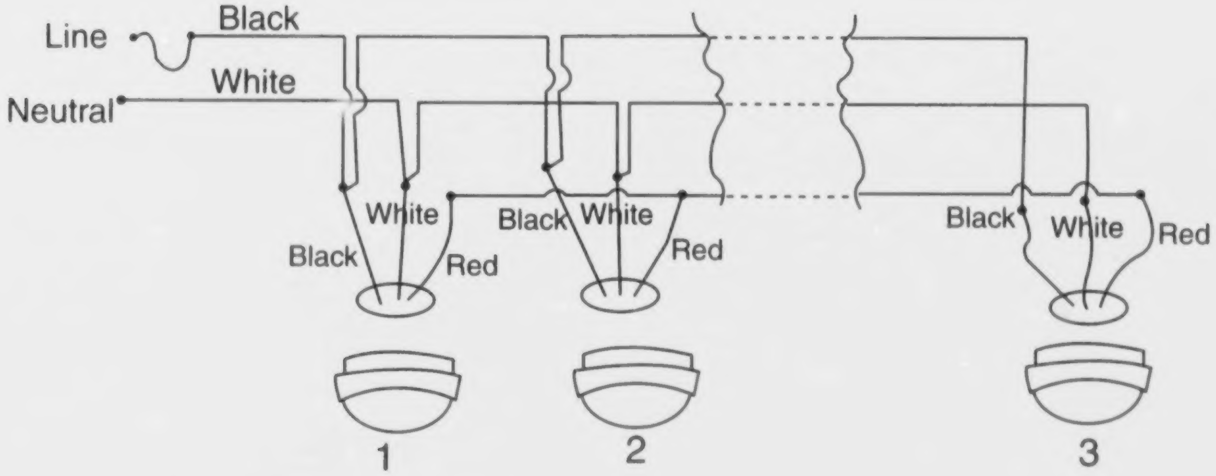
TM 4

Thermostat: Heating Circuit with Automatic Fan Control


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Auto
On
Heat
Off
Cool
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
H
L
C
Heat Elements
Compressor Motor
Fan Motor

TM 5

Smoke Detector: Interconnecting Wiring Diagram


Line
Black
White
Neutral
White
Black
Red
Black
White
Red
Black
White
Red
1
2
3

Unit Contents

Teacher Components

Teacher Page

Suggested Activities 6–3

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Written Test 6–9

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Transparency Masters

1—Operation of an Automated Home 6–17

Student Page

Student Components

Objective Sheet 6–3

Information Sheet 6–5

Student Supplements

1—Home Automation 6–15
2—Low Voltage Blueprint Symbols 6–17

Assignment Sheets

1—Use Article 780 of the *National Electrical Code* to Answer Questions Related to Home Automation Wiring 6–19

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make copies of any teacher supplements that will be provided for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

  TM 1—Operation of an Automated Home (Objective 3)

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.

Suggested Activities

- Have students complete the focus assignment to introduce topics presented in unit of instruction.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheets. Review with students the criteria for evaluation of these activities.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Teaching Suggestions

- Collect and show to class several blueprints of automated homes. Point out some of the special symbols that are found on the blueprints, then have student identify other special symbols related to automated homes.
- Invite local suppliers to class to show various tools. Have them demonstrate the proper use and care of the various tools. Give students an opportunity to ask questions during the demonstration.
- Demonstrate the proper use and care of special tools used in automated home wiring if a local supplier is unavailable.
- If possible, plan an on-site visit to an automated home under construction to show students the various components. Have students take notes on what they observe, then discuss their observations in class.
- Meet individually with students to evaluate their progress through this unit of instruction, and indicate to them possible areas for improvement.

Resources Used in Developing This Unit

Print Media

- *1993 National Electrical Code*. Quincy, MA: National Fire Protection Association, 1992.
- Stauffer, H. Brooke and Ray C. Mullin. *SMART HOUSE Wiring*. Albany, NY: Delmar Publishers Inc., 1993.
- *1999 National Electrical Code*. Quincy, MA: National Fire Protection Association, 1998.

Suggested Supplemental Resources

Print Media

- Briere, Danny and Pat Hurley. *Smart Homes for Dummies*. Foster City, CA: IDG Books Worldwide, Inc., 1999.
- Gerhart, James. *Home Automation and Wiring*. New York, NY: Mcgraw-Hill Publishers, Inc., 1999.
- O'Riley, Ronald P. *Illustrated Changes in the 1999 National Electrical Code*. Albany, NY: Delmar Publishers, Inc., 1999.

Electronic Media

Note: The following internet sites provide information on products, manufacturers, and dealers, or provide access to organizations, magazines or other useful information on home automation.

- www.cedia.org
  Custom Electronic Design and Installation Association
- www.homeautomation.org
  Home Automation Association
- www.homeautomationtimes.org
  magazine
- www.electronichouse.com
  magazine
- www.smarthome.com
  information, catalogs
- www.smart-house.com
  Smart House Incorporated
- www.panja.com
  products and information
- www.amp.com
  catalog
- www.smarthomeinc.com
  products
- www.lutron.com
  products

Answers to Assignment Sheets

Assignment Sheet 1

Use Article 780 of the *National Electrical Code* to Answer Questions Related to Home Automation Wiring

1. 780-3 (b)

   Condition 1—A nominal-operation acknowledgement signal is not being received from utilization equipment.

   Condition 2—A ground fault condition exists.

   Condition 3-–An overcurrent condition exists.

2. 780-3 (d)

   In the event of a controller malfunction, all associated outlets shall be de-energized.

3. 780-5

   For signaling circuits not exceeding 24 volts, the current required shall not exceed one ampere where protected by an overcurrent device or an inherently limited power source.

4. 780-2 (a)

   Except as modified by the requirements of this article, all other applicable articles of this code shall apply.

5. 780-7

   Receptacles, cord connectors, and attachment plugs used on closed-loop power distribution systems shall be constructed so that they are not interchangeable with other receptacles, cord connectors, and attachment plugs.

Written Test

Name ____

Date ______________________________ Score __________

Objective 1

Match the terms related to home automation with their definitions. Write the correct numbers in the blanks.

1. Audio switcher
2. Devices
3. LAN
4. Star configuration
5. Structured cabling
6. Sub-systems
7. System controller

_____ a. Cabling configuration whereby cables are run from each jack or room to a central point in the house, usually the system controller.

_____ b. Can include electric windows, fireplaces, televisions, VCR's, DVD's, CD players, stereos, draperies, pianos, and gates

_____ c. Can include lighting, heating and air conditioning, audio/visual, lawn irrigation and security systems

_____ d. Local area network

_____ e. Referred to as the "brain" of the system, manages all home automation system functions

_____ f. Allows audio sources to be mixed and/or matched to audio zones or rooms

_____ g. Low voltage cable installed in a home to handle the data, video, and audio needs of the home

Objective 2

Define the term "home automation".

____

____

____

____

____

____

Written Test

Objective 3

Draw a diagram showing the operation of an automated home. Use the space provided below.

Objective 4

List six components of a home automation system.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

Objective 5

Match the types of cable used in home automation with their uses. Write the correct numbers in the blanks.

1. Telecommunications cable	4. System cable
2. LAN cable	5. Peripheral device cable
3. Video cable	6. Fiber optic cable

_____ a. Makes it possible to connect digital satellite systems, VCR's, DVD's, security cameras and other types of video in/out put.

_____ b. Used to connect to other devices or communicate with other systems

_____ c. Contains a small filament of glass. Light is sent through the glass, and transceivers at either end transform the light to data and vice versa

_____ d. Makes it possible to attach four separate phone lines to each outlet

_____ e. Makes it possible for the home automation system to communicate with the different components of the system

_____ f. Makes it possible to share computer resources such as programs, printers, and modems

Objective 6

Select true statements concerning types of controllers by placing an "X" in the blanks next to the true statements.

_____ a. One of the advantages of infrared remote controls is that the signal can pass through walls and other obstructions

_____ b. Pressing just one button on a keypad can launch a complex set of instructions or just turn on a light

_____ c. Wireless touch panels can display live video

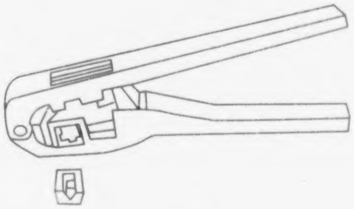
_____ d. The type of construction and the materials in walls can limit the range of radio frequency controllers

_____ e. One of the advantages of keypads is that one single gang box can replace a bank of light switches

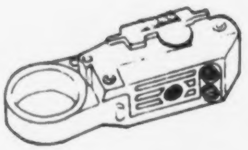
Written Test

Objective 7

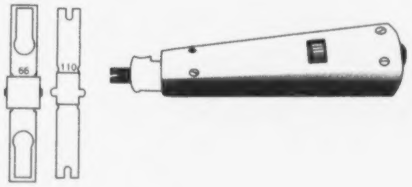
Identify the following special tools used in home automation. Write your answers in the blanks provided.



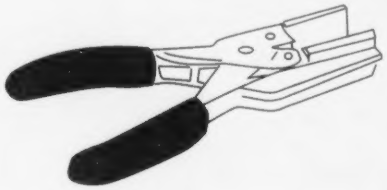
a. ______________________



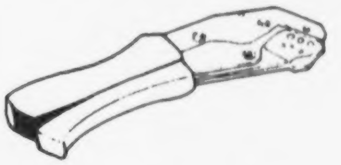
b. ______________________



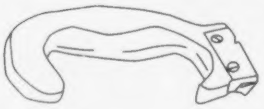
c. ______________________



d. ______________________



e. ______________________



f. ______________________

***Permission to duplicate this test is granted.**

Answers to Written Test

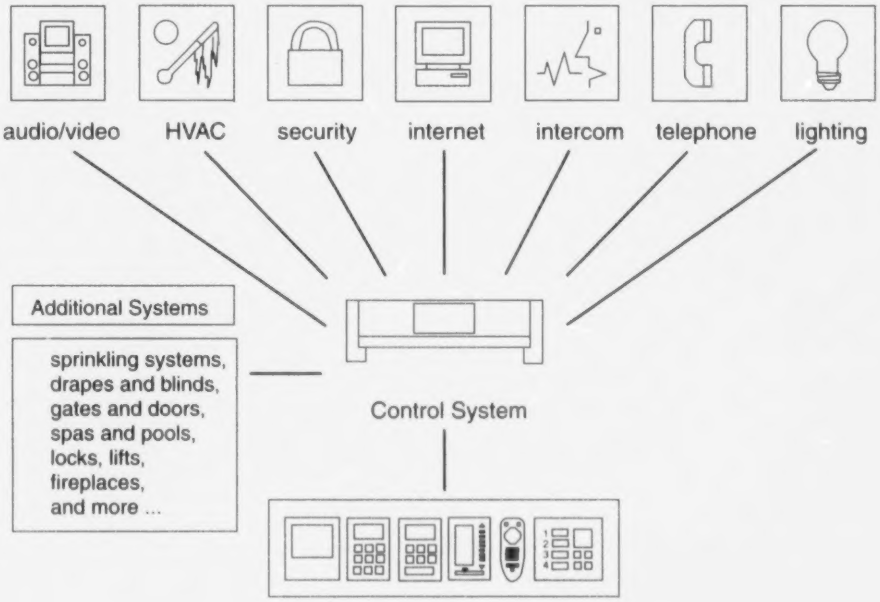
Objective 1

a. 4
b. 2
c. 6
d. 3
e. 7
f. 1
g. 5

Objective 2

A stand alone, computer based home management system that combines today's latest technology with an integrated home network of energy, communication, lighting, audio/visual, security, and peripheral cables. This allows different sub-systems and devices to work together.

Objective 3


audio/video
HVAC
security
internet
intercom
telephone
lighting
Additional Systems
sprinkling systems, drapes and blinds, gates and doors, spas and pools, locks, lifts, fireplaces, and more ...
Control System
1
2
3
4

Objective 4

Answers may be stated in any order.

a. Lighting controls
b. Environmental controls
c. Multi-room/source audio
d. Home electronics
e. Security systems
f. Peripheral systems

Objective 5

a. 3
b. 5
c. 6
d. 1
e. 4
f. 2

Answers to Written Test

Objective 6	b, d, e
Objective 7	a. Modular crimp tool b. Coaxial cable stripper c. Punch down tool d. Application cable tap tool e. Coaxial cable crimper f. Cable slitter

Prerequisites:
None

Learning Activities Sheet

Student Name ____

Place a checkmark in the appropriate box as you complete each of the steps below.

☐ 1. **Take** Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 2. **Read** Objective Sheet.

☐ 3. **Study** Information Sheet, Objectives 1 and 2.

☐ 4. **Read** Student Supplement 1, "Home Automation."

☐ 5. **Study** Information Sheet, Objectives 3 through 7.

☐ 6. **Do** Assignment Sheet 1, "Use Article 780 of the *National Electrical Code* to Answer Questions Related to Home Automation."

☐ 7. **Stop** Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat Steps 5 and 6.

☐ 8. **Read** Student Supplement 2, "Low Voltage Blueprint Symbols."

☐ 9. **Research** Online resources regarding products and information associated with home automation. Visit www.panja.com as one of your resources.

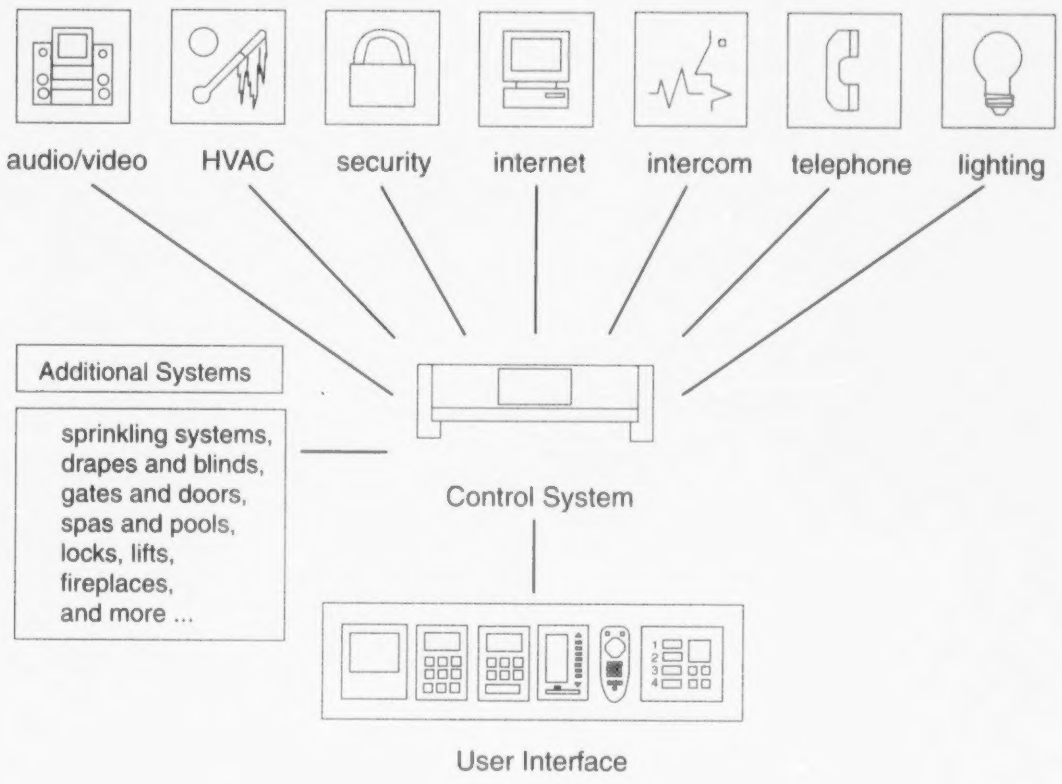
☐ 10. **Check** With instructor for any additional assignments to be completed.

☐ 11. **Take** Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

☐ 12. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

***Permission to duplicate this form is granted.**

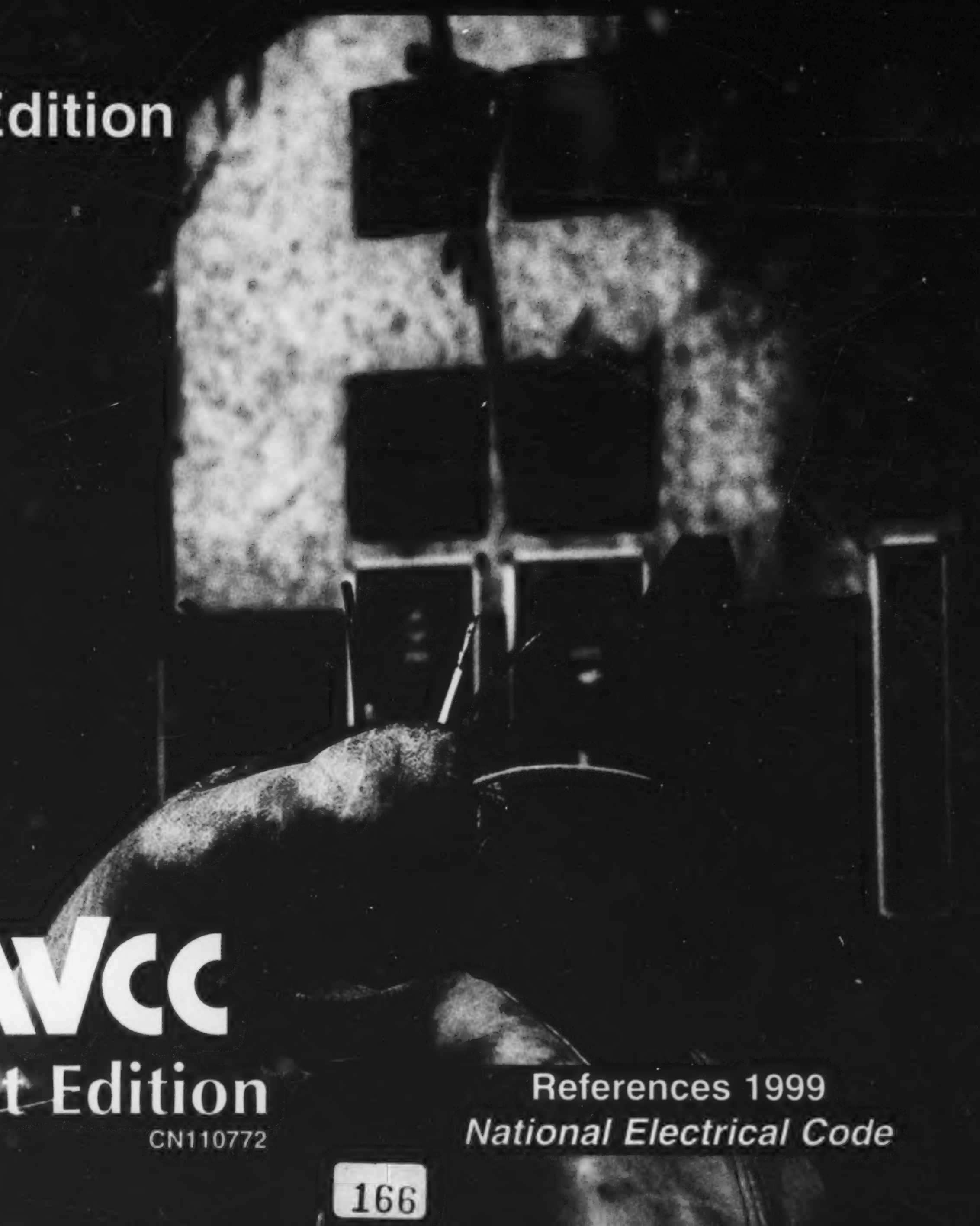
Operation of an Automated Home


audio/video
HVAC
security
internet
intercom
telephone
lighting
Additional Systems
sprinkling systems,
drapes and blinds,
gates and doors,
spas and pools,
locks, lifts,
fireplaces,
and more ...
Control System
1
2
3
4
User Interface

The Home Automation System Provides Two-Way Comunication Between The System Controller, The Various Components, And The User Controls.

RESIDENTIAL WIRING

Third Edition



MAVCC
Student Edition
00-14189 CN110772

References 1999
National Electrical Code

166

Residential Wiring

Third Edition

Student Edition

Written by

Mark Taylor

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Larry Batson
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Dan Ipock
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Todd Onstott

Project coordinated by

Glenn Fleming

Developed by

Multistate Academic and Vocational Curriculum Consortium, Inc.
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Stillwater, Oklahoma 74074-4364

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Phone: (800)654-3988 or (405)743-5578

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Unit 1

Blueprint Reading and Load Calculations

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Objective Sheet

Unit Objective

After completing this unit, the student should be able to interpret blueprint drawings and perform load calculations from the information provided in blueprint drawings and specifications. The student should demonstrate these competencies by completing the assignment sheet and job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to blueprint reading and load calculations with their definitions.
2. Identify blueprint symbols used in residential drawings.
3. Match electrical symbols with their correct descriptions.
4. Match types of lines with their pictures and descriptions.
5. List kinds of information commonly found in blueprint specifications.
6. Select true statements concerning minimum requirements for residential outlets.
7. Calculate circuit loads and voltage drop of a dwelling.
8. Draw receptacle and lighting outlets on a floor plan. (Assignment Sheet 1)
9. Determine general lighting loads. (Assignment Sheet 2)
10. Determine small appliance and laundry loads. (Assignment Sheet 3)
11. Determine total connected load plus total demand load of a dwelling. (Assignment Sheet 4)
12. Locate required receptacle and lighting outlets on a house plan. (Assignment Sheet 5)

Information Sheet

Objective 1

Terms and definitions

a. **Blueprint**—Copy of the original detailed drawings of a structure

b. **Blueprint lines**—A set of conventional symbols to depict an object

c. **Branch circuit**—The circuit that extends from the last overcurrent protection device to the outlets

d. **Dwelling**—One or more rooms used for eating, living, and sleeping, with permanent provisions for cooking and sanitation

e. **Feeder circuit**—All circuit conductors between the service equipment or the source of a separately derived system and final branch circuit overcurrent device

Note: This circuit originates at the service equipment and extends to the subpanel.

f. **Lighting outlet**—An outlet intended for the direct connection of a lampholder or light fixture

g. **Receptacle outlet**—An outlet where one or more receptacles are installed

h. **Service entrance**—The conductors and equipment for delivering electricity from the supply system to the wiring system of the premises served

i. **Specifications**—A detailed set of written instructions which explain the drawing and become part of the contract

j. **Symbol**—An arbitrary sign that has been standardized and is used to represent an object, quantity, or method

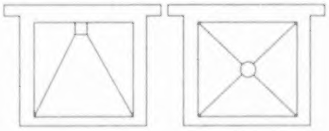
k. **Voltage drop**—A reduction in available voltage at the end of a circuit

Objective 2

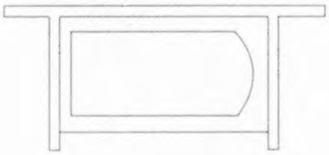
Blueprint symbols used in residential drawings

a. Plumbing

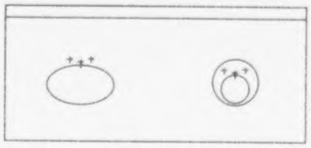
Showers



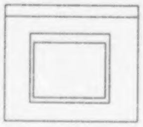
Built-in bathtub



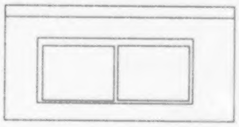
Built-in lavatories



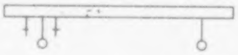
Single bowl sink



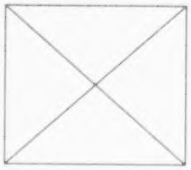
Double bowl sink



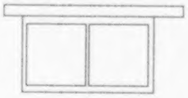
Shower heads



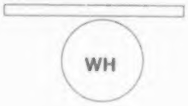
Furnace (designate fuel and capacity)



Laundry tubs

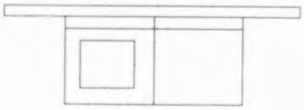


Water heater (designate capacity and fuel)

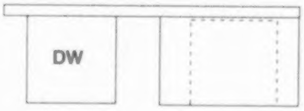


b. Appliances

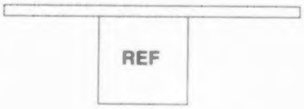
Washer and dryer



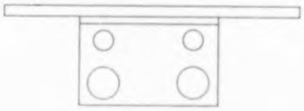
Freestanding and built-in dishwashers



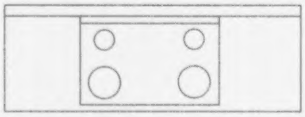
Refrigerator



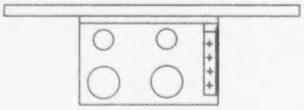
Freestanding range



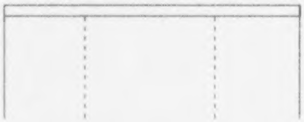
Drop-in range



Surface cook top

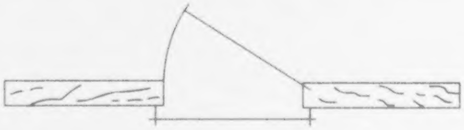


Built-in oven

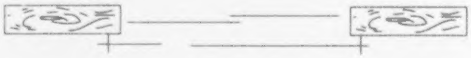


c. Structural symbols

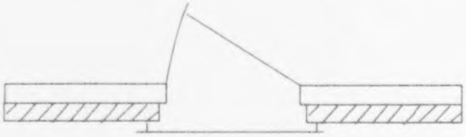
- Plan view of exterior door in wood frame wall



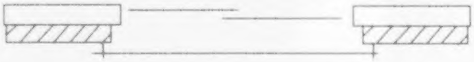
- Plan view of exterior sliding door in wood frame wall



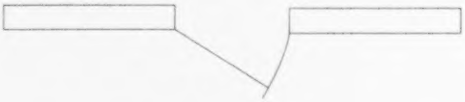
- Plan view of exterior door in masonry veneer wall



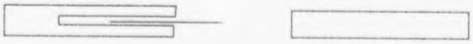
- Plan view of exterior sliding door in masonry veneer wall



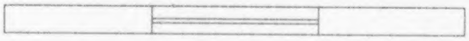
- Plan view of interior hinged door



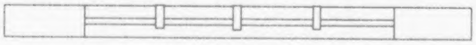
- Plan view of interior pocket door



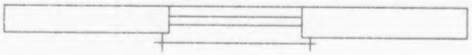
- Single window in frame wall



- Multiple windows in frame wall



- Plan view of double hung window in frame wall

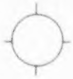


Objective 3

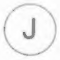
Electrical symbols

a. Convenience outlets

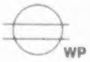
Ceiling outlet



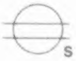
Junction box



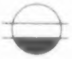
Weatherproof convenience outlet



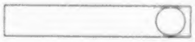
Switch and convenience outlet



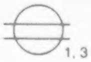
Duplex receptacle split wired



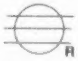
Fluorescent fixture



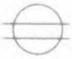
Convenience outlet other than duplex 1=single, 3=triplex, etc.



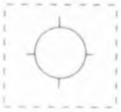
Range outlet



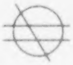
Duplex receptacle



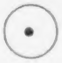
Recessed incandescent



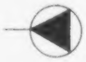
120/240, 1ø combination receptacle



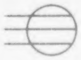
Floor outlet (attach additional symbol for recept. tel., etc.)



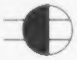
Special outlet—as noted



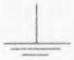
240V, 4W, 3P receptacle—amps as noted



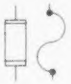
240V, 3W, 2P receptacle—amps as noted



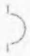
Ground



Fuse



Circuit breaker



b. Switch outlets

S	Single pole switch
S_2	Double pole switch
S_3	Three-way switch
S_4	Four-way switch
S_D	Dimmer switch
S_K	Key operated switch
S_p	Switch with pilot light
S_{MC}	Momentary contact switch
S_{MS}	Motion sensor switch
Ⓣ	Thermostat
Ⓗ	Humidistat

c. Panels, circuits, and miscellaneous

▬	Lighting panel
▨	Power panel
——	Branch circuit; concealed in ceiling or wall
— - —	Branch circuit; concealed in floor
- - - -	Branch circuit; exposed
—➝➝—	Home run to panel board; indicate number of circuits by number of arrows
━━	Feeders

d. Special symbols

SD	Electronic smoke detector
CATV	Cable TV outlet
◀	Phone outlet

Objective 4

Types of lines

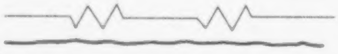
a. Object lines (━━━━━━━━━━━━) show the main outline of the building including exterior walls, interior partitions, porches, patios, driveways, and interior walls; these lines should be the outstanding lines on a drawing.

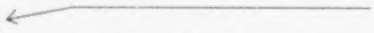
b. Dimension lines (←————————→) are thin unbroken lines upon which building dimensions are placed.

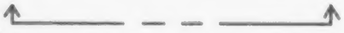
c. Extension lines (————————————) extend, but do not touch, the object lines and permit dimension lines to be drawn between them.

d. Hidden lines (- -) are short dashes used to show lines that are not visible from that view.

e. Center lines (– – ———————————— – – –) are a series of short and long dashes used to designate the centers of doors, windows, and circles and to provide reference points for dimensioning.

f. Break lines () are used when an area cannot or should not be drawn in its entirety.

g. Leaders () are used to connect a note or dimension to a part of the building.

f. Cutting-plane lines () are heavy lines consisting of a series of one long and two short dashes with arrows at each end pointing away from the area that is cut away for the purpose of sectioning.

Objective 5

Information commonly found in blueprint specifications

a. Sizes

b. Types and quality of building materials

c. Methods of construction

d. Material lists

Note: This can include electrical lists as supplied by the electrical contractor in bids to the general contractor.

e. Owner's name and address

f. Contractor's name and address

g. Location of new structure

h. Completion date

i. Contractor's bid

j. Guarantees

k. Blueprint number

Objective 6

Minimum requirements for residential outlets

a. Receptacles—Installed so that no point along the floor lines in any wall space is more than 6 feet from an outlet

b. Switches—Located so that they may be operated from a readily accessible place

Note: Install opposite hinged side of door. Other minimum requirements for switches are covered in *NEC* Art: 380.

c. Lighting—At least one wall switch controlled lighting outlet shall be installed in every habitable room, hall, stairway, attached garage, bathroom, and outdoor entrance to a residence and at least one wall switch controlled light at point of entry to attics, under crawl spaces, basements, when this area is used for storage or containing equipment requiring service

Information Sheet

Objective 7

Calculating circuit loads and voltage drop of a dwelling

a. Branch circuits—All branch circuit loads of a dwelling may be grouped into one of three categories: (1) general lighting load, (2) small appliance and laundry load, and (3) special appliance load.

- General lighting load—To determine the general lighting load, multiply 3 volt amps (watts) times the total square foot area of the dwelling unit.

  Note: *NEC* Table 220-3(a) lists the unit load required per square foot.

- Small appliance and laundry load—The small appliance and laundry loads are figured at 1,500 volt-amps (watts) for each two wire circuit.

  Note: *NEC* Art: 220-16 lists requirements for small appliance and laundry circuits.

- Special appliance load—The special appliance loads are determined by the kilowatt rating listed on the nameplate.

  Note: *NEC* Art: 220-3(b)(1) lists requirements for special appliance loads.

b. Feeder circuits (subpanels)—The computed load for the feeders shall not be less than the sum of the loads on the branch circuits supplied.

Note: *NEC* Art: 220-10 covers feeder calculations.

c. Total load (service)—All loads in a dwelling are not used simultaneously or for extended periods of times. The application of demand factors will produce lower total demand loads. Lower demand loads require small service entrance conductors, resulting in less material cost for the job.

Note: Demand factors for dwelling loads are listed in *NEC* Art's: 220-11 (general lighting and receptacle load), 220-17 (fixed appliance load), 220-18 (dryer load), and 220-19 (range load).

d. Voltage drop—The formula for calculating single-phase voltage drop is,

$$VD = \frac{2L \times K \times I}{A}$$

VD = Voltage drop in..Volts (V)
L = One-way length of circuit conductor (for single-phase) in...Feet (ft)
= Total length of circuit conductor (for 3-phase) in ....Feet (ft)
K = A constant for conductor material in.........................CM-Ohm/ft
I = Current through conductor in ....Amperes (Amp, A)
A = Area of conductor in......................................Circular Mils (CM)

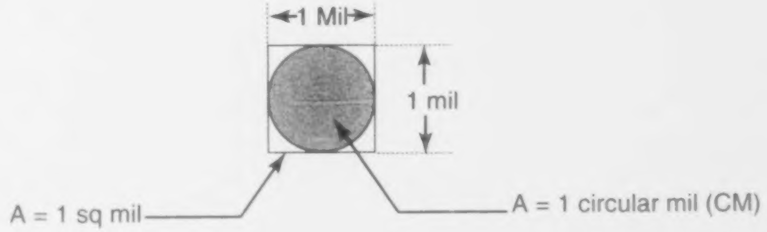
Note: The Mil is a unit of measurement for length and is related to the inch by:

$$1 \text{ mil} = \frac{1}{1000} \text{ inch}$$

or

$$1000 \text{ mils} = 1 \text{ inch}$$

By definition, a wire with a diameter of 1 mil has an area of 1 circular mil (CM) as shown below.



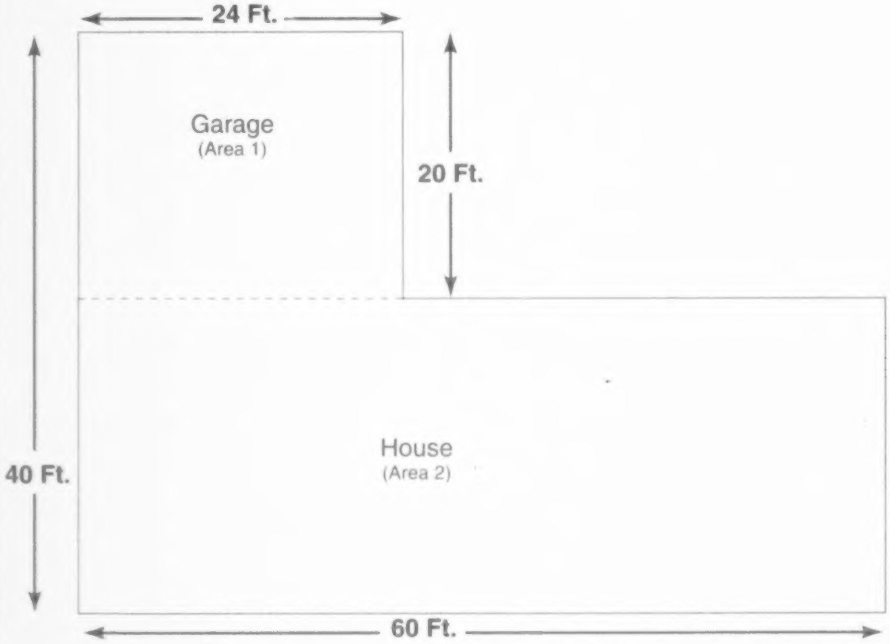
Student Supplement 1—Calculating Square Footage

Introduction

It's essential that you be able to calculate the square footage of a dwelling or living area in order to determine general lighting loads, total demand load, and total connected load.

Directions

Find the square footage of the following dwelling.



Steps

1. Divide the floor plan into 2 rectangles.

   Note: When determining square footage, areas must be divided into squares or rectangles.

2. Find the area of the garage space using the following formula:

   Area (Sq. Footage) = Length x Width
   20 ft. (length) x 24 ft. (width) = 480 square feet

3. Find the area of the living space.

   Determine the length of the living space by subtracting the length of the garage from the total length of the structure.
   40 ft. (total length) – 20 ft. (length of garage) = 20 ft.
   Width = 60 ft. (taken from floor plan)
   20 ft. (length) x 60 ft. (width) = 1200 square feet

4. Add the square footage of each area or rectangle to determine the overall square footage of the dwelling.
   480 square ft. (step 2) + 1200 square ft. (step 3) = 1,680 square feet

Objective 8

Assignment Sheet 1—Draw Receptacle and Lighting Outlets on a Floor Plan

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• *NEC* articles referenced to locate outlets	______
• Outlets placed in correct locations on drawing	______
• Appropriate symbols used	______

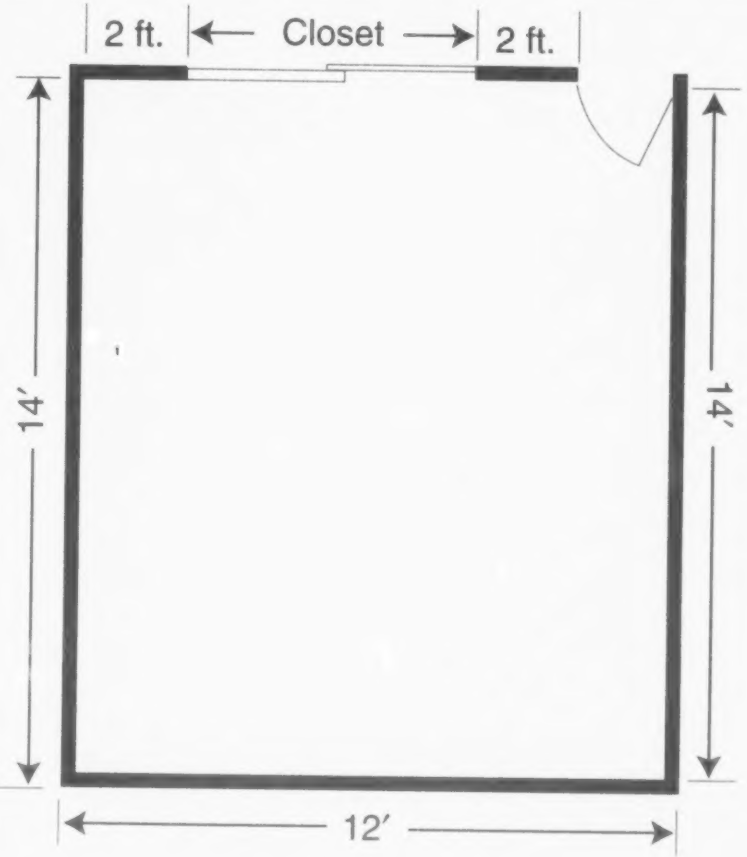
Basic Skills

Reading Writing Mathematics

Directions

Using electrical symbols, draw locations of receptacle outlets and lighting outlets for the floor plan on the back of this page. Refer to *NEC* Art: 210-8, 210-52, and 410-56-58 for minimum spacing and location.

Assignment Sheet 1


2 ft.
Closet
2 ft.
14′
14′
12′

Objective 9

Assignment Sheet 2—Determine General Lighting Loads

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• General lighting load requirements given	______
• Computations shown for each problem	______
• Correct answers given	______

Basic Skills

Reading Mathematics

Directions

List the general lighting loads for the following dwellings. Use *NEC* Art: 220-3(a) to determine general lighting load minimum requirements. Show all computations in space provided.

1. 3200 sq. ft. with no garage. ______________

2. 2750 sq. ft. with no garage. ______________

3. 4100 sq. ft. including a 20 ft. x 24 ft. garage. ______________

4. 1925 sq. ft. including a 7 ft. x 10 ft. front porch. ______________

Objective 10

Assignment Sheet 3—Determine Small Appliance and Laundry Loads

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Used *NEC* to determine minimum requirements	______
• Computations shown for each problem	______
• Correct answers given	______

Basic Skills

Reading Mathematics

Directions

Calculate the small appliance and laundry loads for the dwellings listed below. Use *NEC* Art's: 220-4(a), and 220-16 to determine minimum requirements. Show all computations in space provided.

1. A single family dwelling with one kitchen area and one laundry area. The specifications call for minimum circuits.

2. A single family dwelling with one kitchen area and one laundry area. The specifications call for four circuits in the kitchen area and one circuit in the laundry area.

Objective 11

Assignment Sheet 4—Determine Total Connected Load Plus Total Demand Load of a Dwelling

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Calculated total load accurately	______
• Determined total demand load accurately	______

Basic Skills

Reading Mathematics

Note: Ref. *NEC* Art: 220-3(a). Table will provide proper demand percentage information.

Procedure

1. Table 220-3(a)—Multiply the lighting load of 3VA x the total square footage of the living area
2. Art. 220-16(a)—Multiply the number of small appliance circuits x 1500VA
3. Art. 220-16(b)—Multiply the number of laundry circuits x 1500VA

   Add steps #1 - #3 to obtain the Total Connected Load

4. Table 220-3(a)—Multiply the first 3,000VA x 100%

   Multiply the remaining VA x 35%

   Add the two parts of Step #4 to obtain the Total Demand Load

Example

A single family dwelling has 1452 square feet of living area (120/240 volt single-phase). The dwelling has two small appliance circuits and one laundry circuit.

1.	1452 sq. ft. x 3VA =	4,356VA
2.	2 small appliance circuits x 1500VA =	3,000VA
3.	1 laundry circuit x 1500VA =	1,500VA
	Total Connected Load =	8,856VA
4.	1st 3,000 x 100% =	3,000VA
	Remaining 5,856 x 35% =	2,050VA
	Total Demand Load =	5,050VA

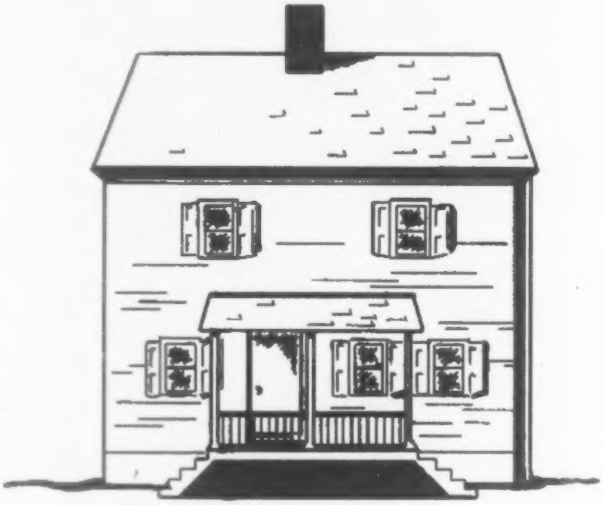
Assignment Sheet 4

Directions

Calculate the total connected load for the dwelling described below. Next apply appropriate demand factors to determine the total demand load.

Problem

2400 Sq. Ft. Dwelling—Dwelling has two small appliance circuits and one laundry circuit.



1. 2400 sq. ft. ______________VA
2. 2 small appliance circuits ______________VA
3. 1 laundry circuit ______________VA

Total connected load ______________VA

4. *NEC* Table 220-3(a) ______________VA

x % ______________VA

x % ______________VA

Total demand load ______________VA

Objective 12

Assignment Sheet 5—Locate Required Receptacle and Lighting Outlets on a House Plan

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Symbol locations for receptacle and lighting outlets meet minimum NEC requirements	______
• Symbols drawn correctly	______
• Symbols used correctly	______

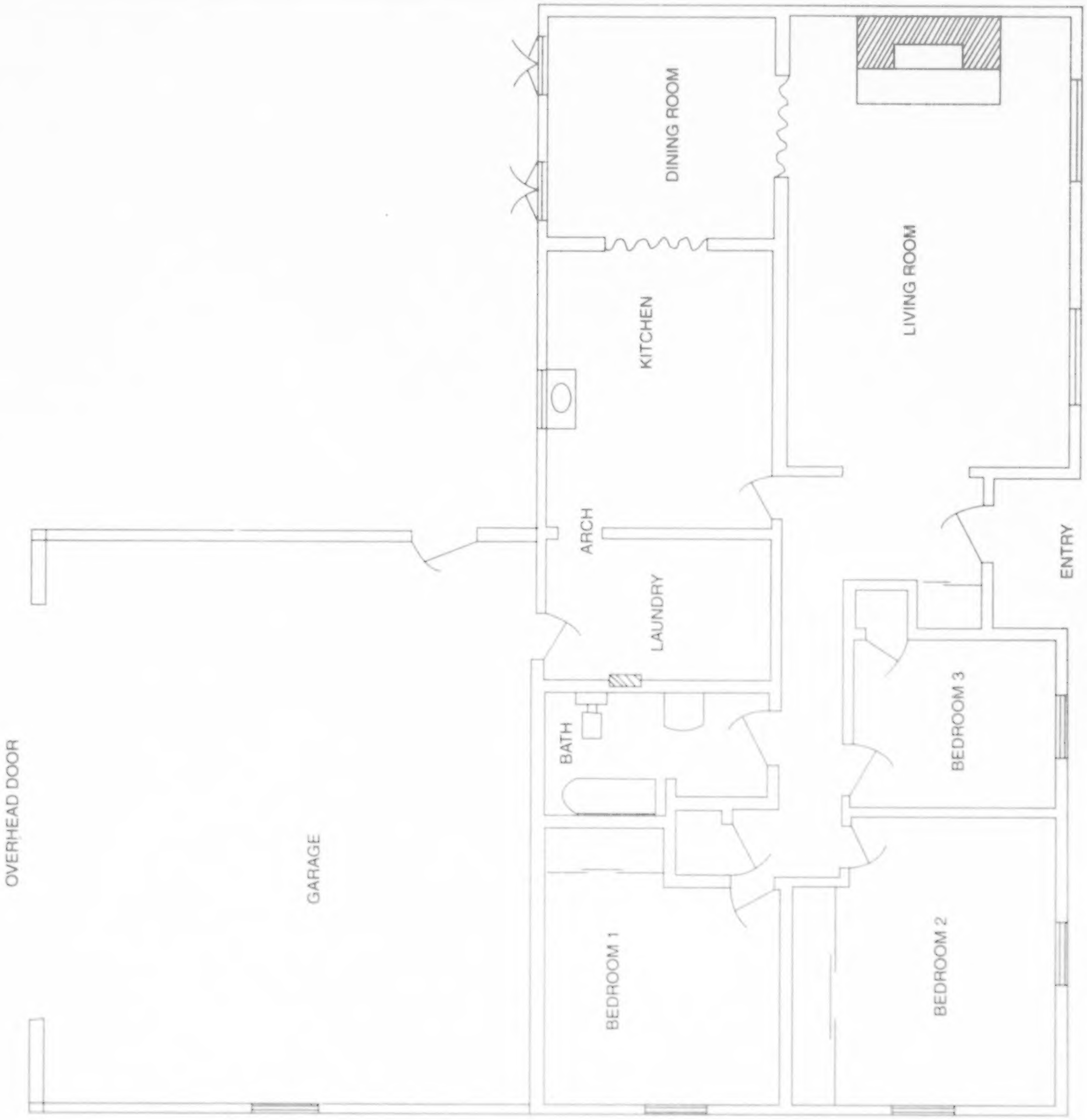
Basic Skills

Reading Writing Mathematics

Directions

Using the information provided in this unit and the *NEC* requirements, draw in the electrical symbols for the receptacle and lighting outlets to meet minimum requirements on the accompanying house plan.

Assignment Sheet 5


DINING ROOM
LIVING ROOM
KITCHEN
ARCH
LAUNDRY
ENTRY
BATH
BEDROOM 3
BEDROOM 1
BEDROOM 2
GARAGE
OVERHEAD DOOR

Electrical Floor Plan Scale 1/8" = 1'

Unit Contents

Student Components

Student Page

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Job Sheets

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2—Connect Meter Base Assembly to Load Center or Panel 2-21
3—Install an underground Service (Lateral) Raceway with Conductors to a Meter Base 2-25
4—Braid the Ground Conductor of a Service Entrance Cable 2-27

Objective Sheet

Unit Objective

After completing this unit, the student should be able to design, size, and install a residential service. The student should demonstrate these competencies by completing the assignment sheets and job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to service with their definitions.
2. Match required clearances for service drop conductors with their locations.
3. Select true statements concerning service disconnects.
4. List four facts that should be known before the service installation is started.
5. Identify the parts of a service entrance.
6. Select from a list, types of grounding electrodes.
7. Select true statements concerning grounding electrode conductor installations and sizes.
8. Select true statements concerning short circuit protection at service equipment.
9. Select true statements concerning surge protection.
10. Calculate service size and minimum number of circuits. (Assignment Sheet 1)
11. Install an overhead raceway with service entrance conductors to a meter base. (Job Sheet 1)
12. Connect meter base assembly to load center or panel. (Job Sheet 2)
13. Install an underground service (lateral) raceway with conductors to a meter base. (Job Sheet 3)
14. Braid the ground conductor of a service entrance cable. (Job Sheet 4)

Information Sheet

Objective 1

Terms and definitions

a. **Circuit Breaker**—A device designed to open and close a circuit by nonautomatic means, and to open the circuit automatically on a predetermined overcurrent without damage to itself when properly applied within its rating

b. **Cutout box**—An enclosure designed for surface mounting and having swinging doors or covers secured directly to and telescoping with the walls of the box proper

c. **Disconnecting means**—A device or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

d. **Grounding electrode conductor**—Conductor used to connect the grounding electrode to the equipment grounding conductor and/or the grounding conductor of the circuit at the service

e. **Main panel**—Consists of a main breaker or pair of fuses. The service conductors enter the service main panel directly from the meter enclosure. The main panel must be located in an accessible place and as close as possible to the point where the service conductors enter the structure

f. **Overcurrent protection**—Weak link in the circuit that limits the amperage to a specified amount

g. **Roof flashing**—Protective equipment used where the mast emerges from the roof or eave to seal around the raceway and protect against water damage

h. **Service**—The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

i. **Service cable**—Service conductors made up in the form of a cable

j. **Service Conductors**—The conductors from the service point to the service disconnecting means

k. **Service drop**—The overhead service conductors from the last pole or aerial support to and including the splicers, if any, connecting to the service entrance conductors at the building or other structure

l. **Service entrance conductors, underground system**—Service conductors between the terminals of the service equipment and the point of connection to the service lateral

m. **Service entrance conductors, overhead system**—Service conductors between the terminals of the service equipment and a point usually outside the building, clear of building walls, where joined by tap or splice to the service drop

n. **Service equipment**—The necessary equipment, usually consisting of a circuit breaker(s) or switch(es) and fuse(s) and accessories, connected to a building or other structure, or an otherwise designated area, and intended to constitute the main control and cutoff of the supply

Note: Overcurrent devices shall not be located in the vicinity of easily ignitable material such as in clothes closets.

o. **Service lateral**—Underground service conductors between the street main, including any risers at a pole or other structure or from transformers and the first point of connection, to the service entrance conductors in a terminal box or meter or other enclosure with adequate space inside or outside the building wall

Note: Where there is no terminal box, meter, or other enclosure with adequate space, the point of connection shall be considered to the point of entrance of the service conductors into the building.

p. **Service mast**—That portion of the service raceway that extends through a roof or eave

q. **Service raceway**—Raceway that encloses the service entrance conductors

r. **Sub-panel**—A panel deriving from the main panel to service another area or building. This panel does not have the service conductors connected

Objective 2

Clearances for service drop conductors not in excess of 600v

Note: *NEC* Art: 230-24 deals with clearances.

a. Over roofs—Not less than 8′ from highest point except where the voltage between conductors does not exceed 600 and:

- If the roof has a slope of not less than 4″ in 12″, a 3′ minimum is permitted on systems which do not exceed 300v between conductors.
- If the conductors do not pass over more than 6′ of overhang and are terminated at a through-the-roof raceway or support, and 18″ minimum is permitted on systems which do not exceed 300v between conductors

Note: Refer to *NEC* Art: 230-24(a) excepton 3

b. From ground vertically

- 10 feet—At the electric service entrance to buildings, or at the drip loop of the building electric entrance, measured from final grade or other accessible surface only for service-drop cables supported on and cabled together with a grounded bare messenger and limited to 150 volts to ground
- 12 feet—For those areas where the voltage is limited to 300V to ground
- 15 feet—For those areas listed in the 12 foot (3.66m) classification where voltage exceeds 300 volts to ground
- 18 feet—Over public streets, alleys, roads, parking areas subject to truck traffic, driveways on other than residential property, and other land traversed by vehicles such as cultivated, grazing, forest, and orchard

  Note: Refer to *NEC* Art. 234-24(b)

Objective 3

Service disconnects

a. Maximum number of service entrance disconnects—Not more than six switches or circuit breakers in single enclosurers or grouped on a switchboard.

Note: *NEC* Art: 230 deals with services. Where a residence requires more than six circuits, a main breaker is generally used.

b. Transfer switches—A double throw switch is used to transfer the alternate source of supply in case main service is lost. The transfer switch must disconnect the main service before connecting the alternate source. This switch may be manually or automatically operated.

Note: *NEC* Art: 230-76 deals with transfer switches.

Objective 4

Facts that should be known before the service installation is started

a. Whether underground or overhead service will be used

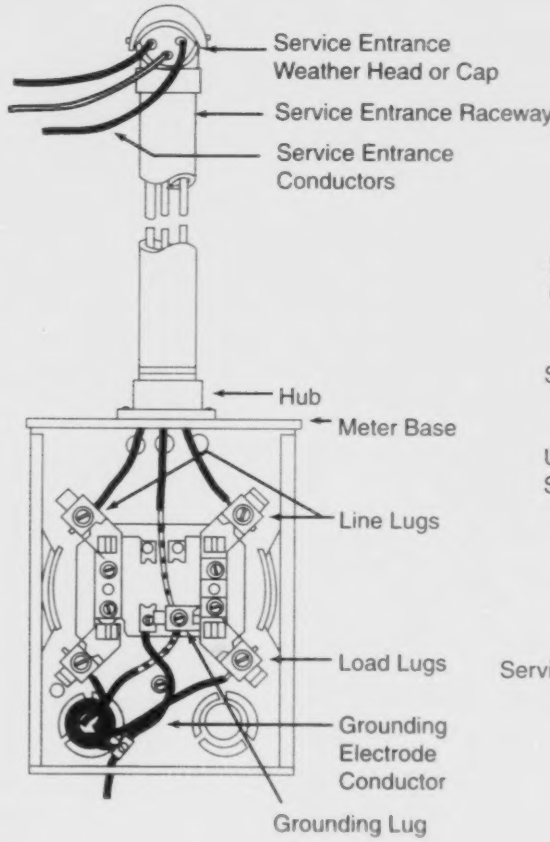
b. Voltage and amperage of service needed

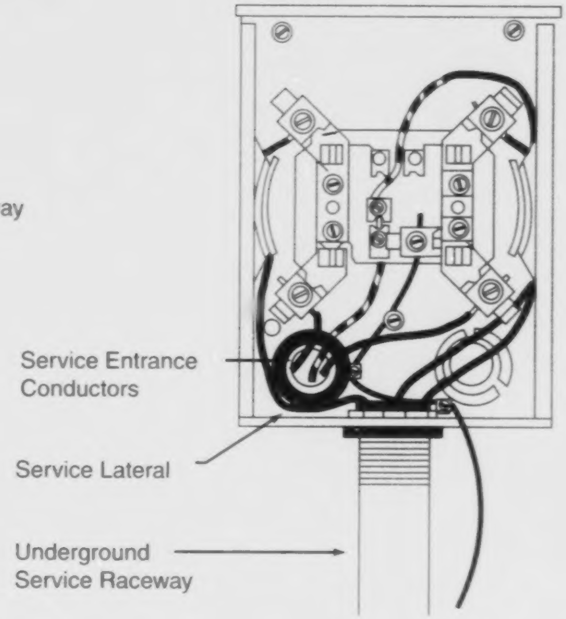
c. Point at which service conductors are to enter the building

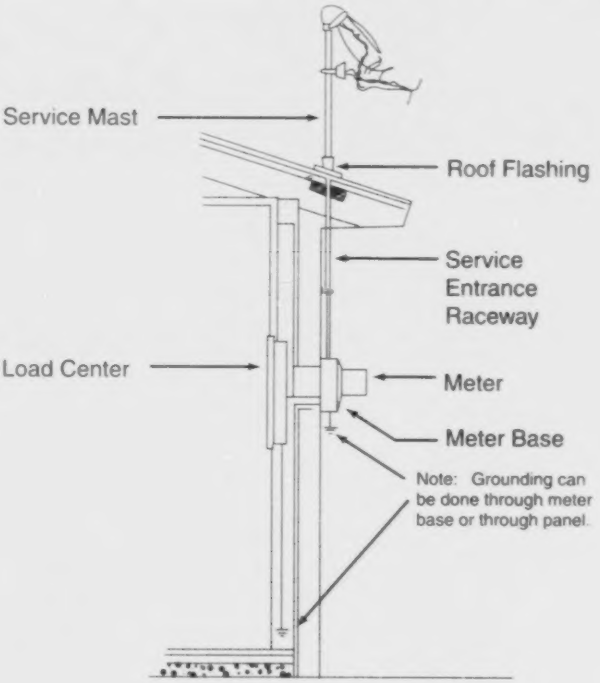
d. Size of service equipment needed

Information Sheet

Objective 5 | **Parts of a service entrance**


Service Entrance Weather Head or Cap
Service Entrance Raceway
Service Entrance Conductors
Hub
Meter Base
Line Lugs
Load Lugs
Grounding Electrode Conductor
Grounding Lug


Service Entrance Conductors
Service Lateral
Underground Service Raceway


Service Mast
Roof Flashing
Service Entrance Raceway
Load Center
Meter
Meter Base

Note: Grounding can be done through meter base or through panel.

Objective 6

Types of grounding electrodes

Note: Refer to *NEC* Art 250

Note: Portable Earth/Ground Resistance Testers are used to determine the resistance of earth surrounding a ground rod, and to check grounds to determine compliance with *NEC*, OSHA, and other specifications. They are available in a variety of designs and can cost anywhere from $500 to over $2,000.

a. Structural metal—Nearest available effectively grounded structural metal member of the structure

b. Water pipe—Metal water pipe for the first five feet from supply shall be used when available

   Note: It should be in direct contact with earth for 10 feet or more and electrically continuous to the points of connection of the grounding electrode conductor and the bonding conductors. Refer to *NEC* Art: 250-50(a).

c. Concrete encased electrodes—At least 20′ of bare copper conductor not smaller than No. 4 AWG or one or more steel reinforced bars or rods of not less than 1/2″ diameter encased in at least 2″ of concrete in a foundation or footing

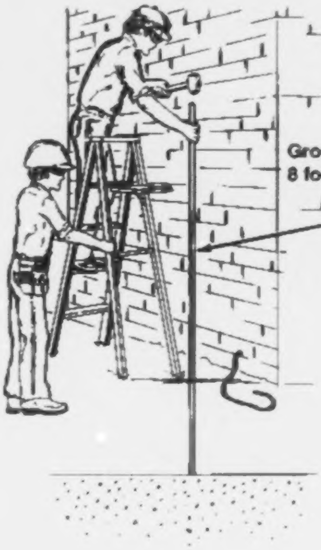
d. Ground ring—A grounding ring encircling the building or structure, in direct contact with the earth at a depth below the earth's surface of not less than 2 1/2 feet (762mm), consisting of at least 20 feet (6.1m) of bare copper conductor not smaller than No. 2.

e. Made electrodes

   Note: Refer to *NEC* Art: 250-52 c.

   - 8′ lengths of:
     - 3/4″ galvanized pipe
     - 5/8″ iron or steel rod
     - 1/2″ nonferrous rod (listed copper, brass, stainless steel, and other noncorrosive materials)

- Plate electrodes—Not less than 2′ square


Ground rod must be 8 foot in length

Note: Where a rock bottom is not encountered, the electrode shall be driven to a length of 8′. Where rock is hit at less than 4′, the electrode shall be buried in a trench. A metal underground water pipe shall be supplemented by an additional electrode as specified in *NEC* Articles 250-50(2).

Objective 7

Grounding electrode conductor installations and sizes

Note: Refer to *NEC* Art: 250.

a. Conductors and enclosurers shall be secured to the surface they follow.

b. #6 or larger conductors
   - Must be in conduit if subject to physical damage.
   - If free from physical damage, it may follow the surface of building if stapled securely.
   - Aluminum or copper clad aluminum cannot be used in contact with masonry or earth.

c. The grounding electrode conductor shall be sized in accordance with Section 250-66, but the tap conductors shall be permitted to be sized in accordance with the grounding electrode conductors specified in section 25-66 for the largest conductor serving the respective enclosurers. The tap conductors shall be connected to the grounding electrode conductor in such a manner that the grounding electrode conductor remains without a splice or joint. For information on connections to other grounding electrodes, see section 250-66(a) through (c).

   Note: Grounding electrode conductor sizes are determined by referring to *NEC* Table 250-64

Objective 8

Short circuit protection at service equipment

a. Service equipment must be able to withstand the fault-current that the power company's transformer could deliver in case of a short-circuit condition.

b. Overcurrent protection devices must be selected to interrupt instantaneous short-circuit currents (fault currents).

Note: The following table represents the "Rule of Thumb" method for finding IC (interrupting capacity) ratings for fuses or circuit breakers, Check with your local power company.

Ampacity of Service	Service Rating	IC Rating
120/240V 1 Ph	Less than 200 A	10,000 A
120-240V 1 Ph	Less than 600 A	42,000 A
120-240V 3 Ph	Less than 2000 A	42,000 A

c. Formulas for short circuit calculations include:

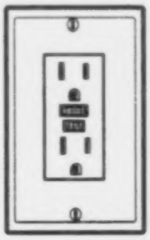
- Single phase, $I = \frac{KVA \times 1000}{E}$
- Three phase, $I = \frac{KVA \times 1000}{E \times 1.73}$

Objective 9

Surge protection

Note: *NEC* Art: 280 deals with surge arresters.

a. Voltage surges with peaks of several thousand volts, even on 120V circuits, are not uncommon. These surges occur because of induced voltages in power lines resulting from lighting strikes in the vicinity of the line. Surge arresters for installation as part of an electric service and for use with cord-and-plug connected electronic equipment are commercially available.



b. Lightning surge arresters must fulfill the following functions:

- They must not allow the passage of current to ground as long as the voltage is normal.

- When the voltage rises to a definite amount above normal, they must provide a path to ground for discharge of surge energy.
- As soon as the voltage has returned below the setting of the arrester, the arrester must stop the flow of current to ground and re-insulate itself so as to insulate the supply conductor from ground.
- Arresters must not be damaged by the discharge, and be capable of automatically repeating their actions as frequently as is required.

Objective 10

Sizing the service entrance conductors

Note: In Unit 1, Blueprint Reading and Load Calculations, we learned the procedure for various circuit calculations. It is now necessary to carry those calculations one step further to determine the size of service entrance conductors.

Note: For a one-family dwelling, the feeder disconnecting means shall have a rating of not less than 100 amperes, 3-wire.

a. Using the examples shown below, determine the size of the service entrance required for the described dwelling.

PROBLEM: Determine the size service-entrance conductors required for Phases A and B, and the neutral of a 2,000 sq. ft. dwelling unit with the following loads:

- General lighting and receptacle loads
- Two small appliance loads and one laundry load
- Special appliance loads

Two wall-mounted 4kVA ovens	8,000 VA
Cooktop	6,500 VA
Heating	25,000 VA
Air conditioning	9,000 VA
Water heater	5,000 VA
Dishwasher	1,200 VA
Disposal	1,000 VA

OTHER LOADS

Step 1: Table 220-30.

General lighting and receptacle loads:
2,000 sq. ft. x 3 VA = **6,000 VA**

Small appliance loads:
1,500 VA x 2 = **3,000 VA**

Laundry load:
1,500 VA x 1 = **1,500 VA**

Wall-mounted ovens:
4 kVA x 2 = **8,000 VA**

Cooktop = **6,500 VA**

Water heater = **5,000 VA**

Dishwasher = **1,200 VA**

Disposal = **1,000 VA**

Total loads = **32,200 VA**

ANSWER: The other loads are 32,200 volt-amps.

HEATING LOAD

Step 1: 220-21

Drop smallest of heating or air conditioning load

ANSWER: The heating load is 25,000 volt-amps.

APPLYING DEMAND FACTORS
Other loads

Step 1: Table 220-30(b)

First 10,000 VA at 100% = 10,000 VA
Next 22,200 VA at 40% = 8,800 VA

ANSWER: The demand load is **18,880 volt-amps**

HEATING LOAD

Step 1: Table 220-30c(4)

25,000 VA x 65% = 16,250 VA

ANSWER: The demand load is **16,250 volt-amps.**

Step 1: Add all loads

Other loads = 18,800 VA
Heating load = 16,250 VA

18,800 VA + 16,250 VA = **35,130 VA**

b. Take the total connected demand load of 35,130 VA and divide it by the voltage.

$$\frac{35{,}130\text{ VA}}{240\text{ Volts}} = 146\text{ Amps}$$

c. Go to Table 310-16, Column 2 of the *NEC* to find that 2 #1/0 THW copper conductors are required. The neutral loads should now be determined. See example.

TOTAL NEUTRAL LOADS

Step 1:

220-22. General lighting and receptacle loads:
6,000 VA

220-16(a,b). Small appliance loads:
4,500 VA

6,000 VA + 4,500 VA = 10,500 VA

General lighting and receptacle loads and small appliance loads:
10,500 VA

Table 220-11. First 3,000 VA at 100% = 3,000 VA
Next 7,500 VA at 35% = 2,625 VA

3,000 VA + 2,625 VA = **5,625 VA**

Table 220-19, Column C. Cooking Equipment

14,500 VA x 65% = 9,425 VA

220-22. 9,425 VA x 70% = **6,598 VA**

220-3(c)(1). Dishwasher = **1,200 VA**
220-3(c)(2). Disposal = **1,000 VA**

220-14. Largest motor x 25%
1,000 VA x 25% = **250 VA**

Total neutral loads = **14,672 VA**

Step 2: $I = \frac{VA}{V}$

$$I = \frac{14{,}672\ \text{VA}}{240\ \text{V}} = 61\ \text{A}$$

ANSWER: The neutral load is 61 amps.

d. Size of the service entrance conductors required for this dwelling are:

- Phases A and B:
  Table 310-16, Column 2: Two #1/0 THW copper conductors are required.
- Neutral:
  Table 310-16, Column 2: One #6 THW copper conductor is required.

  Note: Note 3 to *NEC* Tables 310-16 — 310-31 may be applied.

Objective 11

Assignment Sheet 1—Calculate Service Size and Minimum Number of Circuits

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	Rating
• Complied with *NEC*	______
• Calculated service size correctly	______
• Calculated number of circuits correctly	______

Basic Skills

Reading

Mathematics

Directions

Using the standard code procedure listed below, calculate service size and minimum number of circuits on the following single family dwelling.

Note: Refer to *NEC* Chapter 9—Tables and Examples. Example No. 1(a).

Dwelling has a floor space of 2,100 square feet. It also has an 11 kw electric range.

General lighting load

1. ____________ sq. ft. x 3 watts per sq. ft. = 2. ____________

Minimum number of branch circuits

General lighting load 3. ____________ ÷ 120 = 4. ____________ ÷ 20 =

5. ____________ or number of general lighting circuits

Note: This number always rounds to next whole number if a fraction appears.

Small appliance load: Two 2-wire 20 ampere circuits.
Laundry load: One 2-wire 20 ampere circuit.

Minimum size feeders required

Computed load

General lighting	6. ___________	watts
Small appliance	+3,000	watts
Laundry	+1,500	watts
Total connected load (without range)	7. ___________	watts
Total connected load (with range) (see Table 220-19, col. A)	8. ___________	watts
Total demand load (without range)	9. ___________	watts
Total demand load (with range)	10. ___________	watts

For 120/240 volt 2-wire system feeders, net computed load (without range)

11. ___________ ÷ 240 = 12. ___________ amperes.

For 120/240 volt 2-wire system feeders, net computed load (with range)

13. ___________ ÷ 240 = 14. ___________ amperes.

Size of the service entrance conductors required for this dwelling are:

Note: Refer to *NEC* Table 310-16, column 2.

Without range — 15. ___________ THW copper conductor

With range — 16. ___________ THW copper conductor

Objective 12

Job Sheet 1—Install an Overhead Raceway With Service Entrance Conductors to a Meter Base

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Service mast straight and tight	______
• Service conductor formed properly	______
• Service conductors extend beyond riser cap proper length	______
• Proper connection of line conductor to supply lugs	______
• Proper connection of neutral conductor to neutral lugs	______
• Workmanship	______
• Compliance to *NEC*	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

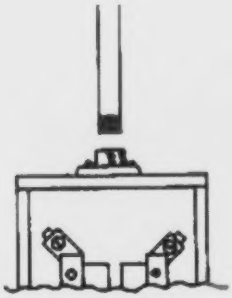
- Flat blade screwdriver
- Lineworker's pliers
- Hammer
- Knife
- Hacksaw
- Folding rule with sliding scale
- Meter base
- Service entrance cap ($1^1/2''$ clamp-on type)
- 3′ of $1^1/2''$ rigid metal conduit (threaded on one end)
- 12′ of #2 copper TW (two 6′ pieces)
- 6′ of #4 copper
- Safety glasses

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

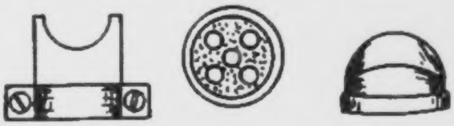
☐ 2. Screw threaded end of raceway into hub.

Figure 1



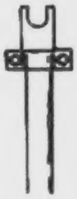
☐ 3. Remove cover and separator from weatherhead.

Figure 2



☐ 4. Clamp weatherhead base onto the end of the service raceway.

Figure 3



☐ 5. Install conductors in the raceway.

Note: Start at weatherhead end.

☐ 6. Connect grounded conductor to grounding lug.

Note: When possible, leave grounded conductor long enough to connect to disconnect equipment grounding bar.

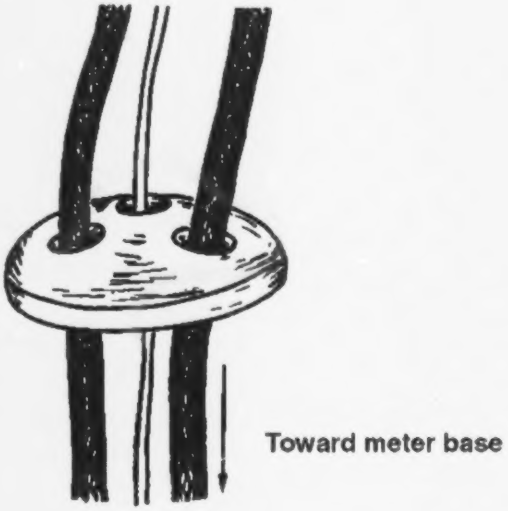
☐ 7. Remove 1″ to 1$^{1}/_{2}$″ of insulation from ungrounded conductors and connect to line lugs.

☐ 8. Knock out three outlined holes in the entrance cap separator.

☐ 9. Put grounded conductor through center hole.

☐ 10. Put ungrounded conductors through side holes.

Figure 4



☐ 11. Gently start forming conductors so the separator will fit back in the base.

Note: Care must be taken while you are bending the curvature in the conductors to prevent damage to the plastic conductor separator.

☐ 12. Replace service entrance cap cover.

☐ 13. Have instructor check your work

☐ 14. Retain meter base for use in Job Sheet 2.

☐ 15. Clean work area and put away all un-needed equipment and materials.

Note: Review the equipment and materials list in Job Sheet 2 prior to completing Step 15.

Evaluator's Comments: ______________________________

Objective 13

Job Sheet 2—Connect Meter Base Assembly to Load Center or Panel

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Meter base is straight and level	____
• Raceway is mounted securely	____
• Correct connection made (ungrounded conductor to ungrounded [top] lugs)	____
• Correct connection made (grounded conductor to grounded lug)	____
• All conductors formed correctly	____
• All connections secure	____
• Workmanship	____
• Compliance to *NEC*	____

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Screwdriver
- Lineworker's pliers
- Hammer
- Knife
- Level
- Rule
- Awl
- Meter base assembly from Job Sheet 1
- Two 1$^{1}/_{4}$″ insulating bushings
- Four 1$^{1}/_{4}$″locknuts
- One 1$^{1}/_{4}$″reamed nipple long enough to connect meter base to distribution panel

  Note: Nipple, bushings, and locknuts can be larger than 1$^{1}/_{4}$″ if conductor size or necessity mandates.

- #4 copper (1 piece)
- #2 TW copper (2 pieces)
- Eight 1″ #12 metal tapping screws
- One 100 amp 1 phase 3 wire SN. load center
- One 1$^{1}/_{2}$″ rigid conduit strap
- 2″ x 4″ mock up wall or roughed in residential dwelling
- Safety glasses

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount load center between studs with metal tapping screws.

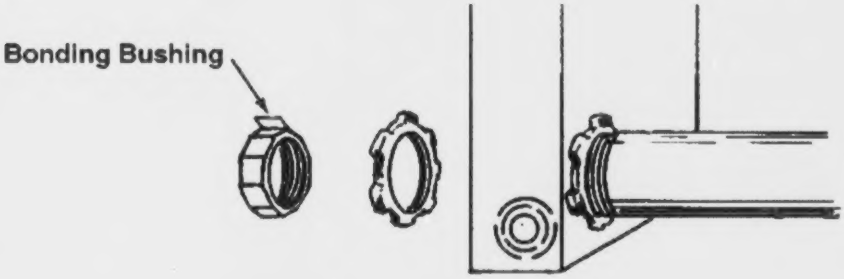
Note: Panel height should be adjusted so that knockouts will line up with meter base between 5′ and 6′. The utility company will give you their recommended height.

☐ 3. Remove load center knockout that will align with meter base at correct height.

☐ 4. Install nipple in opening with a locknut on the backside of load center and a locknut and bushing on the inside. (Figure 1)

Note: Be sure that locknuts are installed tightly with teeth into the metal. Also be sure to check local codes on bonding.

Figure 1



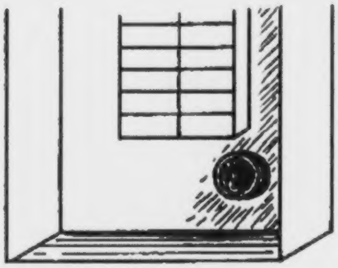
☐ 5. Remove appropriate knockout from meter base.

☐ 6. Put back up locknut for meter base on nipple.

☐ 7. Place nipple through meter base knockout and secure loosely with one screw.

Note: Cut off excess nipple; leave only what is needed for locknut and bushing.

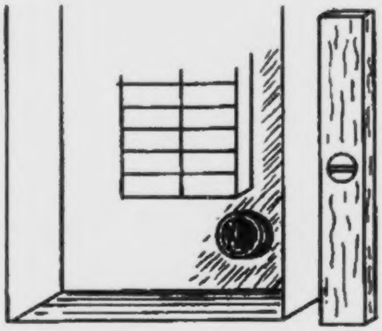
Figure 2



☐ 8. Install internal locknut and bushing.

☐ 9. Place level on side of meter base and secure with mounting screws when leveled.

Figure 3



☐ 10. Put level on service raceway and secure with strap when leveled.

☐ 11. Install grounded conductor in nipple and connect to meter base and load center grounded lugs.

Note: Make all bends in conductors as square as possible while maintaining a radius equal to at least five times the diameter. Make sure you stay as far as possible from load and line lugs in your routing of the grounded conductors.

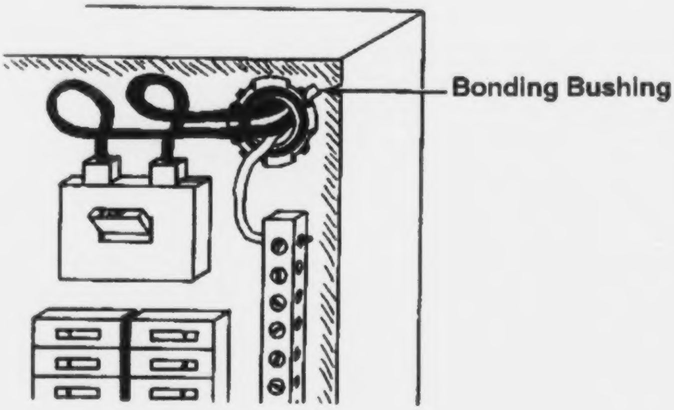
☐ 12. Install ungrounded conductors in nipple.

☐ 13. Strip about 1 1/2" insulation from each of the ungrounded conductors, form them, and connect to meter load lugs.

☐ 14. Form ungrounded conductors in load center.

☐ 15. Cut off excess and connect to load center line lugs.

Figure 4



Note: The service system is still without a grounding electrode conductor. This conductor can originate at the load center or in the meter base. It can terminate at a cold water pipe or made electrode.

☐ 16. Have instructor check your work.

☐ 17. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

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Objective 14

Job Sheet 3—Install an Underground Service (Lateral) Raceway with Conductors to a Meter Base

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Assembly mount at proper height	
• Correct connections made (ungrounded conductor to ungrounded lugs and main breaker)	
• Correct connections made (grounded conductor to grounded lugs in panel and meter base)	
• All threaded connections tight	
• All conductor connections secure	
• Assembly level and straight	
• Workmanship	
• Compliance to *NEC*	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Flat blade screwdriver
- Lineworker's screwdriver
- Knife
- Hacksaw
- Folding rule or tape measure
- Meter base
- 3′ of 2″ rigid nonmetallic tubing (PVC)
- One—2″ PVC 90° elbow
- One—2″ PVC coupling
- One—2″ PVC male adapter
- One—2″ locknut
- 10′ of 3 conductor #1/0 use (underground service entrance, suitable for direct burial)
- Safety glasses

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount meterbase.

Note: Meter base height should be adjusted to conform with local utility company requirements. (See your instructor.)

☐ 3. Install PVC 90° elbow onto 2″ conduit, using the 2″ coupling.

Note: For the purpose of this procedure it will not be necessary to use the PVC cement to bond the parts together.

☐ 4. Measure the assembled conduit parts to fit the bottom of the meter base.

Note: Deduct approximately 1/4″ of the space needed by the male adapter.

☐ 5. Cut off excess conduit from opposite end of 90° elbow.

☐ 6. Install male adapter onto conduit.

☐ 7. Remove knock-out in bottom of meter base (only 2″).

☐ 8. Install conduit assembly (conduit, male adapter, coupling, and 90° elbow) into meter base knock-out.

☐ 9. Install locknut onto male adapter threads inside meter base and tighten.

Note: Be sure teeth of locknut are turned into metal.

☐ 10. Feed conductors up through raceway into meter base.

☐ 11. Strip approximately 1-1½″ of insulation from each of the ungrounded conductors.

Note: Ground conductor of 3 wire URD cable will be marked with a white or yellow stripe.

☐ 12. Form and install ungrounded conductor to the line legs of meter base.

Note: Supply conductors always attach to the line lugs of a meter base. With underground service installation, these conductors must form through the meter base and connect to the top line lugs. **NEVER** attach supply conductors to the bottom lugs; these are for load conductors only.

☐ 13. Strip form and install the grounded conductor.

Note: This conductor should be formed through the meter base and attached to the top lug of the grounded terminal in the meter base.

Note: This service is still without a grounding electrode conductor. This conductor can originate at the load center or in the meter base. It can terminate at a cold winter pipe or made electrode. Consult local inspection authority for requirements or see your instructor.

☐ 14. Have instructor check your work.

☐ 15. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 15

Job Sheet 4—Braid the Ground Conductor of a Service Entrance Cable

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- SE cable
- Knife
- Safety glasses
- Lineman's pliers

Procedure

☐ 1. Put on safety glasses.

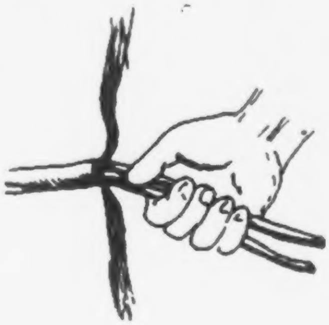
☐ 2. Gather equipment and materials.

☐ 3. Strip off a length of the outer sheath.

Note: Always use safe work practices when using a knife.

☐ 4. Separate ground strands into two separate groups.

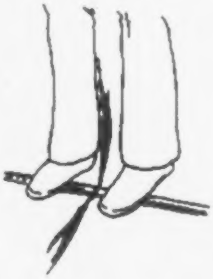
Figure 1



☐ 5. Stand on cable. (Figure 2)

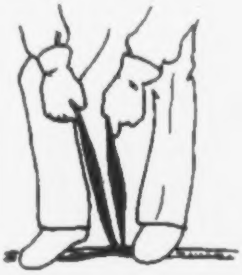
Note: Be sure that the conductors are not on rocks or other materials that could damage the insulation while you have them secured.

Figure 2



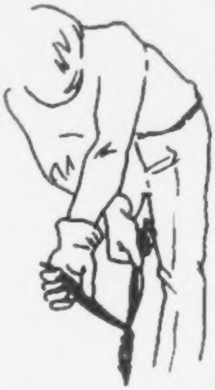
☐ 6. Bend over and grasp the separated neutral. (Figure 3)

Figure 3



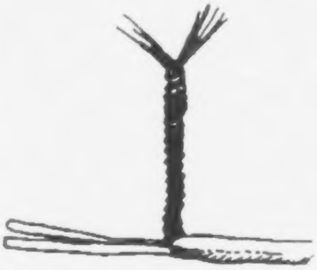
☐ 7. Twist the conductor together while pulling upward. (Figure 4)

Figure 4



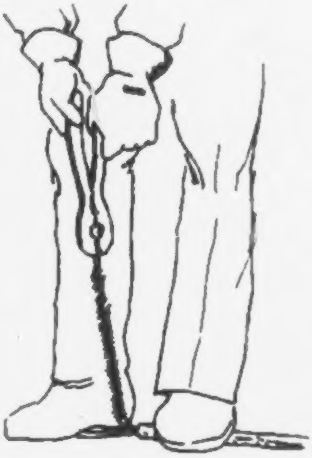
☐ 8. Braid as far as possible by hand. (Figure 5)

Figure 5



☐ 9. Twist with pliers until braid is continuous and uniform. (Figure 6)

Figure 6



☐ 10. Have instructor evaluate your work.

☐ 11. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Unit Contents

Student Components

Student Page

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Focus Assignment

List Systems That Must Be Installed in a Residence Prior to Installing the Wall Finish 3–11

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2—Locate Receptacle Outlets Along Kitchen Cabinets 3–15
3—Locate Receptacle Outlets in a Bathroom 3–17

Objective Sheet

Unit Objective

After completing this unit, the student should be able to install receptacle, switch, and lighting outlets for a residential dwelling. The student should demonstrate these competencies by completing the focus assignment, job sheets, and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to rough-in with their definitions.
2. List six locations where at least one receptacle outlet is required.
3. Select true statements concerning planning techniques when placing boxes on plans.
4. Complete statements concerning accepted heights for boxes in various locations.
5. Select true statements concerning the procedure for installing boxes in exterior walls to be brick veneered.
6. Distinguish between box extensions for noncombustible and combustible wall surfaces.
7. List two common methods of finding room centers.
8. Select true statements concerning required outlets.
9. List seven locations requiring GFCI protection.
10. List rules for electrical installations.
11. List systems that must be installed in a residence prior to installing the wall finish. (Focus Assignment)
12. Locate receptacle, switch, and lighting outlets along a floor line and the ceiling on a blueprint. (Assignment Sheet 1)
13. Locate receptacle outlets along kitchen cabinets. (Assignment Sheet 2)
14. Locate receptacle outlets in a bathroom. (Assignment Sheet 3)

Information Sheet

Objective 1

Terms and definitions

a. **Appliance branch circuit**—A 120V branch circuit rated at 1500VA (20 amps) supplying energy to one or more outlets to which appliances are to be connected

b. **Backsplash**—That portion of a wall behind the kitchen cabinet, starting at the countertop and could extend to the bottom of the wall hung cabinets

c. **Box center**—Midpoint on a boxes vertical dimension

d. **Box set out**—Distance that the box extends past the stud

e. **Flush**—Even with the surface

f. **Habitable**—Suitable for people to occupy or live in

g. **Room center**—Point in a room that is equal distance from parallel walls

h. **Switch leg**—Conductor that carries electrical energy from the switch to the load

i. **Tile cap**—Final tile in a ceramic backsplash when the tile is terminated at some point up the wall

Objective 2

Locations where at least one receptacle outlet is required

a. Bathroom—Adjacent to sink, but not more than 36″ away from the edge of the sink.

b. Laundry

c. Outside (2 minimum)

d. Basement (unfinished portions)

e. Attached garage

f. Hallway (lengths of 10ft or more)

Objective 3

Planning techniques when placing boxes on plans

a. Keep spacing even where possible

b. Put boxes in even groups if possible

c. Check door swing direction so switches are not behind doors

d. Place outside lighting outlets low enough for any fixture

Objective 4

Accepted heights for boxes in various locations

Note: You should ask the cabinetmaker how tall the countertop and backsplash are going to be when you are unfamiliar with the cabinetmaker's work.

a. Above kitchen counter top—45″ to box center

Note: Tops are usually 36″, 1/2 of 18″ backsplash equals 9″, total height is then 45″ from finished floor, but not more than 18 in. above the counter top Ref. Art 210-52(c)(5).

b. Above bathroom countertops—40″ to box center

Note: This allows for a 44″ or higher tile cap.

c. Receptacles along floor line—12″ to box centers

d. Wall switches—50″ to box centers from finished floor

Objective 5

Procedure for installing boxes in exterior walls to be brick veneered

Note: Before installing any boxes in exterior brick walls, check your local code.

a. Punch a small hole in wall sheeting.

b. Push cable through newly formed hole.

c. Put the cable through the back knockout of your box and secure with a cable clamp.

Note: Leave plenty of cable so the mason can move the box to fit the masonry work.

d. Put screws in the device securing holes.

Note: This keeps the screw holes from becoming filled with mortar.

Objective 6

Box extensions for noncombustible and combustible wall surfaces (*NEC* Art 370-20)

a. Non combustible materials—Not more than 1/4″ recess from surface

b. Combustible materials—Flush with or projecting from surface

Objective 7

Common methods of finding room centers

a. Corner to corner chalk line and plumb bob transfer

b. Measuring half wall lengths, out at right angles from the walls

Objective 8

Required outlets

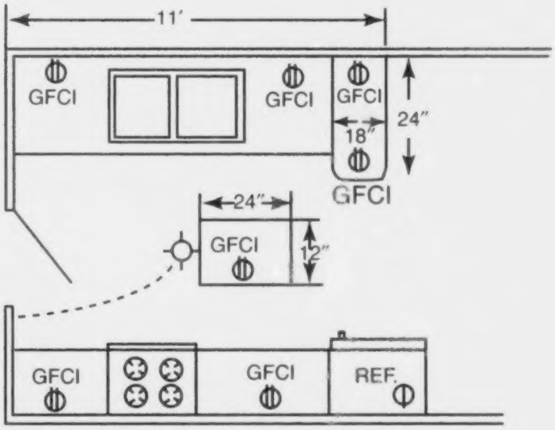
a. Receptacle outlets

- In every kitchen, family room, dining room, living room, parlor, library, den, sunroom, bedroom, recreation room, or similar room or area of dwelling units. Receptacles shall be installed so that no point along the floor line in any wall space is more than 6 feet measured horizontally, from an outlet in that space, including any space 2 feet or more in width, space occupied by fixed panels in exterior walls, excluding sliding panels, the space afforded by fixed room dividers such as free-standing bar-type counters or railings. Floor receptacles may be counted as part of the required number of receptacles if located within 18 inches of the wall.

- Counter tops—In kitchen and dining areas of dwelling units, a receptacle outlet shall be installed at each counter space wider than 12 inches. Receptacle outlets shall be installed so that no point along the wall line is more than 24″ measured horizontally.

  Note: Counters divided by ranges, sinks, or refrigerators shall be considered separate cabinets. Refer to *NEC* Art: 210-52(c)(4).

  Note: 210-52(b) 1, 2, 3 require two or more 20 amp small appliance branch circuits to serve these counter top receptacles.



  Note: Islands and peninsular counter spaces are covered in Art. 210-52(c)(2&3).

- Bathrooms—At least one receptacle outlet shall be installed adjacent to the basin location, but not more than 36″ from the outside edge of the basin

  Note: Refer to *NEC* Art: 210-52(d).

  Note: See Art 100 for definition of bathroom

- Outdoors—At least one receptacle outlet shall be installed at the front and back of the dwelling

  Note: Refer to *NEC* Art: 210-52(e)

- Laundry areas—At least one receptacle outlet shall be installed in laundry areas.

  Note: Refer to *NEC* Art: 210-52(f)

- Basements and attached garages—At least one receptacle outlet shall be installed in addition to any for laundry equipment

  Note: Refer to *NEC* Art: 210-52(g)

- Hallways—10 feet or more

b. Lighting outlets required—At least one wall switch controlling a lighting outlet in every habitable room including the hallway, bathroom stairway, attached garage, outdoor entrance, and in attics, under floor space, utility rooms, and basements if used for storage or of containing equipment requiring service.

Note: In habitable rooms, other than kitchens or bathrooms, one or more receptacles controlled by a wall switch shall be permitted in lieu of lighting outlets.

Note: *NEC* Art: 200-7(c)(2) requires the white or natural gray conductor used as a switch leg to be re-identified by painting or other effective means where the conductor is accessible.

Note: *NEC* Art: 210-70(a)(2) requires a switch to be located at each level of interior stairways where the difference between floor levels is 6 steps or more.

Note: *NEC* Art: 210-70(a)(1) exception 2 allows occupancy sensors instead of wall switches under certain conditions.

c. Attic space—At least one receptacle is required if equipment needing service is contained

Objective 9

Ground-fault circuit-interrupter protection for personnel.

All 125-volt, single-phase, 15-and 20-ampere receptacles shall have ground-fault circuit-interrupter protection for personnel if the receptacles are located in:

a. Bathrooms

b. Garages

c. Outdoors

d. Crawl spaces

e. Unfinished basements

f. Kitchens (counter top)

g. Wet bar sinks (within 6 ft.)

Objective 10

Rules for electrical installations

a. Always be safety conscious.

b. Do work you will be proud of.

c. Be sure all connections are secure and well insulated.

d. Always be sure that overcurrent protection is matched to your conductor rating.

e. Preform conductors before installing devices in boxes.

f. Use appropriate tools.

g. Always meet or exceed *NEC*, state, and local code minimum installation requirements.

Objective 11

Focus Assignment—List Systems That Must Be Installed in a Residence Prior to Installing the Wall Finish

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Identify different residential systems	______
• List residential systems	______

Basic Skills

Reading Writing Critical Thinking

Directions

List all the "systems" that must be installed in a residence before the wall finish can be installed.

Example: Electrical Wiring System

Be prepared to discuss your answers in class.

Objective 12

Assignment Sheet 1—Locate Receptacle, Switch, and Lighting Outlets Along a Floor Line and the Ceiling on a Blueprint

Name ______________________ Overall Rating __________

Date ______________________

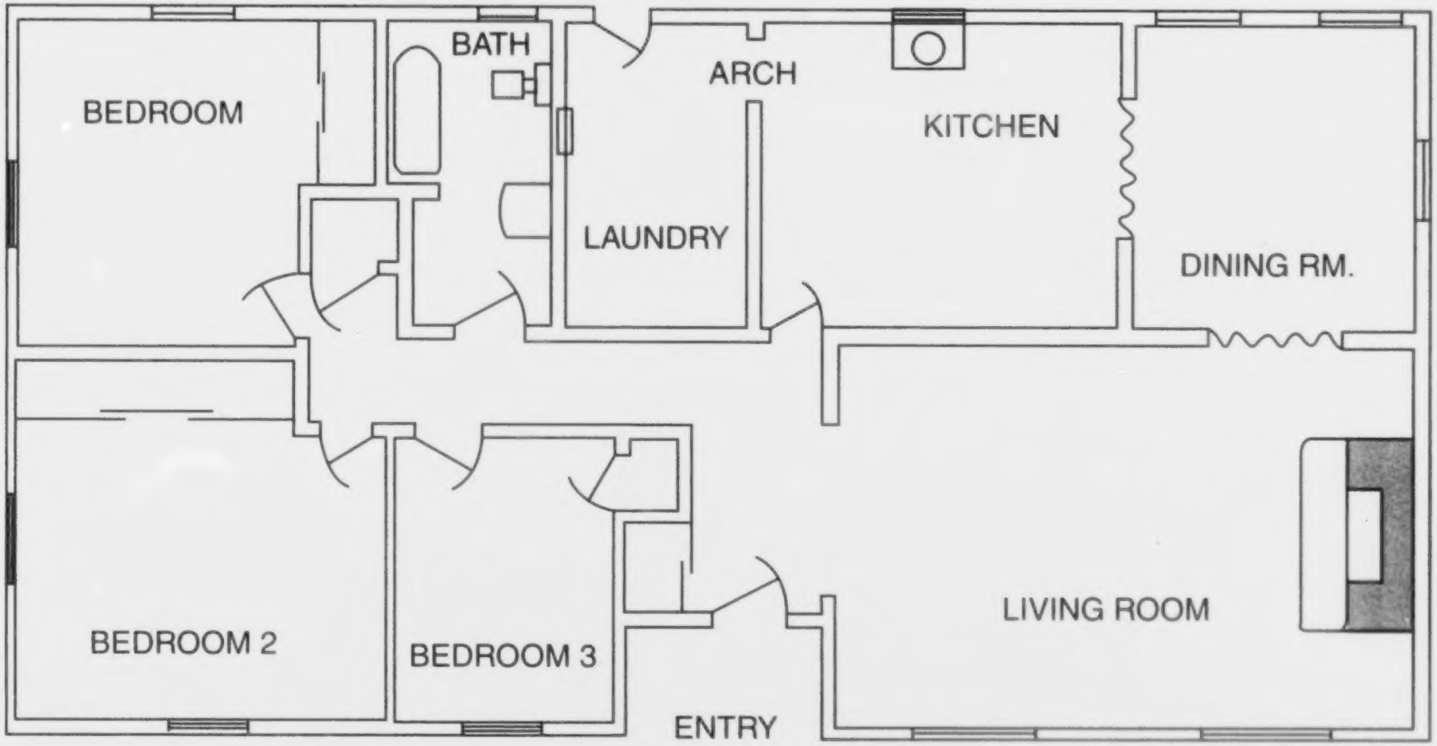
Evaluation Criteria	Rating
• Used appropriate blueprint symbols	_____
• Located minimum required receptacle switch and lighting outlets	_____
• Neat, legible work	_____

Basic Skills

Reading Writing Critical Thinking

Directions

Using appropriate blueprint symbols, locate the minimum required receptacle switch and lighting outlets along the floor line and in the ceiling on the plan on the following page.


BEDROOM
BATH
ARCH
KITCHEN
LAUNDRY
DINING RM.
BEDROOM 2
BEDROOM 3
LIVING ROOM
ENTRY

Electrical Floor Plan
Scale: 1/8″ = 1 Foot

Objective 13

Assignment Sheet 2—Locate Receptacle Outlets Along Kitchen Cabinets

Name ______________________ Overall Rating __________

Date ______________________

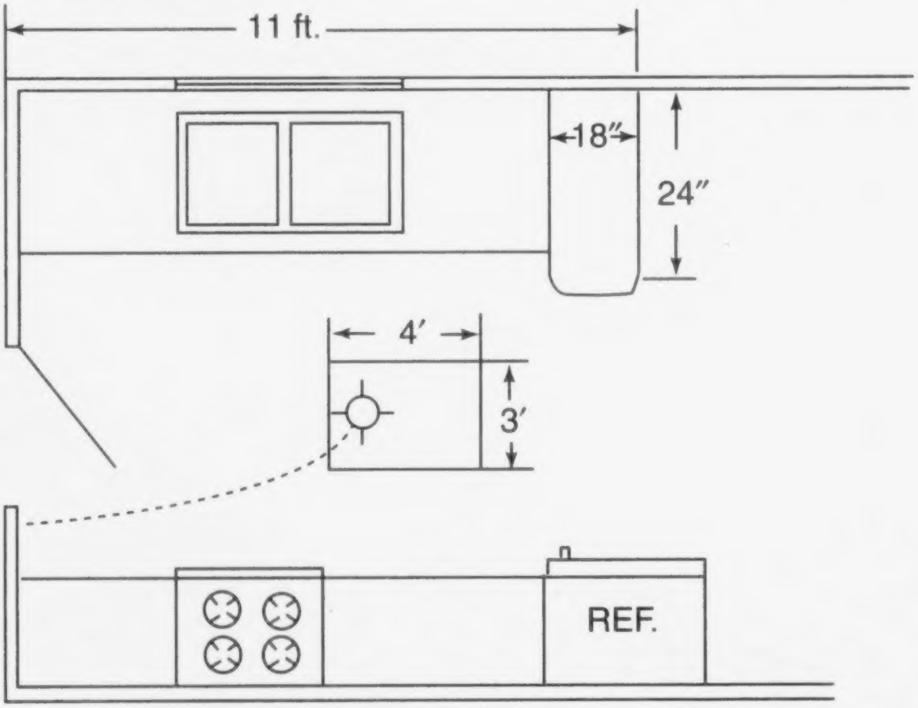
Evaluation Criteria	Rating
• Used appropriate blueprint symbols	______
• Located minimum required receptacle outlets	______
• Neat legible work	______

Basic Skills

Reading Writing Critical Thinking

Directions

Using appropriate blueprint symbols, locate the minimum required receptacle outlets along the cabinet spaces on the print below. Identify GFCI requirements if applicable.



Objective 14

Assignment Sheet 3—Locate Receptacle Outlets in a Bathroom

Name ______________________ Overall Rating __________

Date ______________________

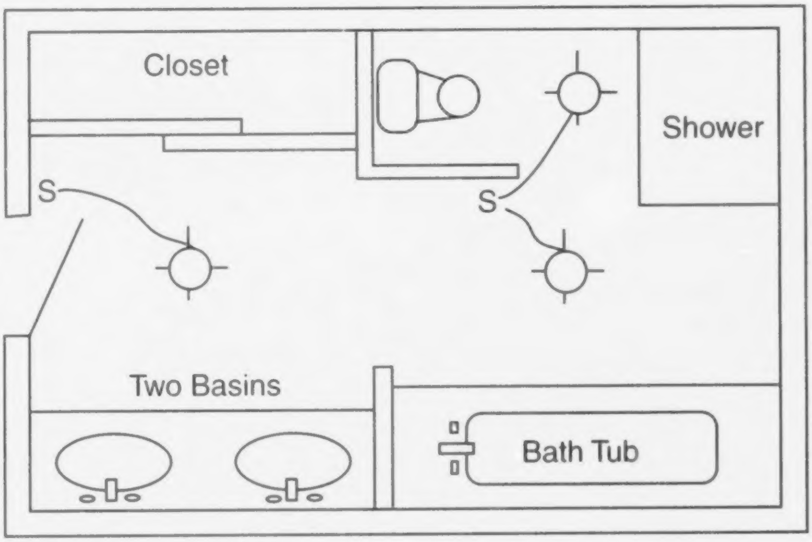
Evaluation Criteria	Rating
• Used appropriate blueprint symbols	______
• Located minimum required receptacle outlets	______
• Neat legible work	______

Basic Skills

Reading Writing Critical Thinking

Directions

Using appropriate blueprint symbols, locate the minimum required receptacle outlet(s) on the bathroom space below.



Unit 4

Trim Out and Troubleshooting

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List and Price Lighting Fixtures 4–19

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3—Wire a receptacle fed from a lighting outlet through a three-way switch 4–35
4—Wire a four-way switching situation with the supply entering the lighting outlet box 4–41
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8—Install a fixed appliance equipped with a pigtail to a branch circuit . . 4–59
9—Install a multi-circuit split-wired duplex grounding type receptacle . . 4–63
10—Install a fusible safety switch for an air-conditioning condenser . . . 4–67

Objective Sheet

Unit Objective

After completing this unit, the student should be able to perform trim out for a residential wiring system and troubleshoot electrical problems for new and existing dwellings. The student should demonstrate these competencies by completing the focus assignment, assignment sheet, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to trim out and troubleshooting with their definitions.
2. Identify common residential receptacle types and cover plates.
3. Identify common residential switch types and cover plates.
4. Match common residential fixture locations with their types.
5. Match appliance classifications with their descriptions.
6. Distinguish between requirements for appliance disconnect means.
7. State the grounding requirements for appliances.
8. Identify the parts of a duplex grounding type receptacle.
9. Identify the parts of an equipment grounding system.
10. Arrange in order the steps for panel trim out.
11. Select true statements concerning troubleshooting procedures.
12. List and price lighting fixtures (Focus Assignment)
13. Troubleshoot Electrical Problems (Assignment Sheet 1)
14. Wire a receptacle fed from a lighting outlet through a single pole switch (Job Sheet 1)
15. Wire a switch controlled split-wired receptacle (Job Sheet 2)
16. Wire a receptacle fed from a lighting outlet through a three-way switch (Job Sheet 3)
17. Wire a four-way switching situation with the supply entering the lighting outlet box (Job Sheet 4)
18. Mount a fan box according to manufacturer's recommendations (Job Sheet 5)

Objective Sheet

19. Install a range or dryer receptacle (Job Sheet 6)
20. Connect a supply cord to a free standing range or dryer (Job Sheet 7)
21. Install a fixed appliance equipped with a pigtail to a branch circuit (Job Sheet 8)
22. Install a multi-circuit split-wired duplex grounding type receptacle (Job Sheet 9)
23. Install a fusible safety switch for an air-conditioning condenser (Job Sheet 10)

Information Sheet

Objective 1

Terms and definitions

a. **Appliance**—Utilization equipment, generally other than industrial, normally built in standardized sizes or types, which is installed or connected as a unit to perform one or more functions such as clothes washing, air conditioning, food mixing, or deep frying

b. **Appliance (cord and plug connected)**—Portable, and in some cases, stationary appliances permitted to be connected by a flexible cord

c. **Appliance (fastened in place)**—Permanently mounted in place and usually hard wired

d. **Appliance (small) branch circuit**—A 120V branch circuit rated at 1500 VA (20 amps) supplying energy to one or more outlets to which appliances are to be connected

e. **Cable clamp**—Piece of equipment used to secure cables

f. **Device**—Unit of an electrical system which is intended to carry but not utilize electrical energy

g. **Disconnecting means**—A device, or group of devices, or other means by which the conductors of a circuit can be disconnected from their source of supply

h. **Duplex grounding receptacle**—A single yoke device with two grounding type receptacles

i. **Feed through**—The use of a box for splicing or rerouting conductors to get to another location

j. **Individual branch circuit**—Branch circuit that supplies only one piece of utilization equipment

k. **Line leg**—Conductor that supplies electrical energy to a switch

l. **Multiple receptacle**—A single yoke device with two or more receptacles

m. **Pigtail**—Splicing technique that leaves an accessible conductor for termination at a device, load, or grounding terminal

n. **Poles**—Current carrying conductors, both grounded and ungrounded, on a receptacle switch or overcurrent device

o. **Receptacle connecting fin**—Detachable design feature that makes terminals common connections

p. **Single receptacle**—A single contact device with no other contact device on the same yoke

q. **Split-wired receptacle**—Receptacle that has had a connecting fin removed for remote control or separate circuit connections

r. **Strap or yoke**—Metal strip containing one or more devices

s. **Switch**—Device used to open or transfer circuit direction

t. **Switch leg**—Conductor that carries electrical energy from the switch to the load

u. **Switch loop**—Conductors between light and switch when supply enters the light

v. **Terminal**—Point of attachment for conductors

w. **Traveler**—Transfer conductors in a switching situation; they are used between 3-ways and 4-ways

x. **Trim out**—Final stage in a residential wiring project; involves devices and plates, connecting and securing equipment, hanging fixture, and testing the system

y. **Troubleshooting**—The systematic diagnosis of a malfunction

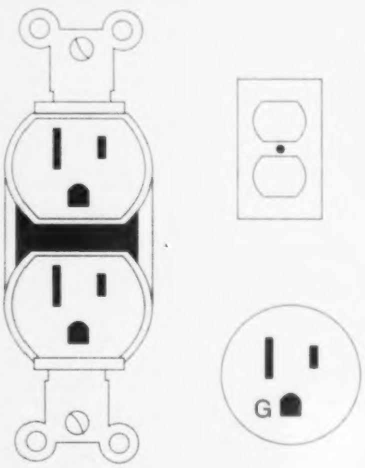
z. **Volt ampere**—Voltage multiplied times amperage

aa. **Wires**—Current carrying conductors and grounding conductors

Objective 2

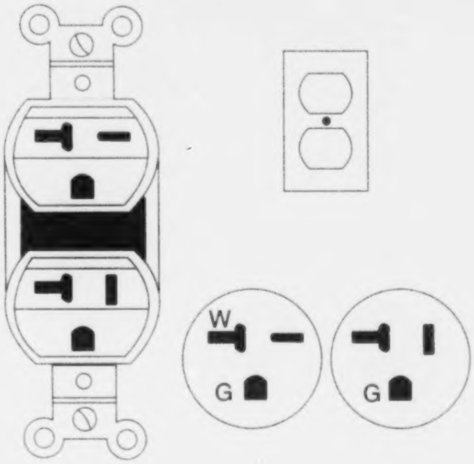
Common residential receptacle types and cover plates

a. Duplex grounding receptacle 125v, 15 amp



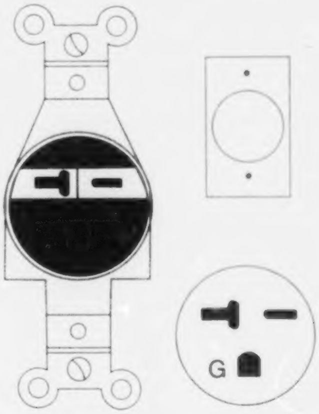
Note: There are a wide variety of styles and colors available for devices and cover plates.

b. Dual voltage receptacle 125/250, 20 amp



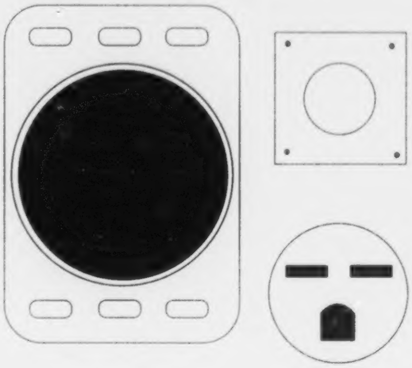
Note: This outlet is configured so-as to not allow plug attachment to wrong voltage.

c. Air conditioner receptacle 250v, 20 amps

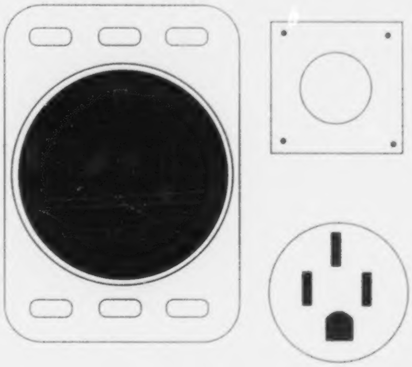


Note: This is often referred to as a "T" blade receptacle.

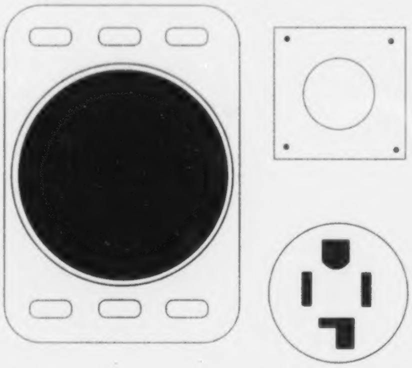
d. Air conditioning receptacle 250 volt, 30 amp



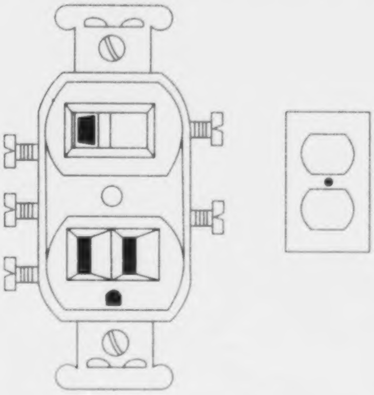
e. Range receptacle 125/250v, 50 amp



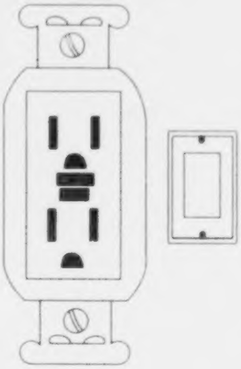
f. Dryer receptacle 125/250 volt, 30 amp



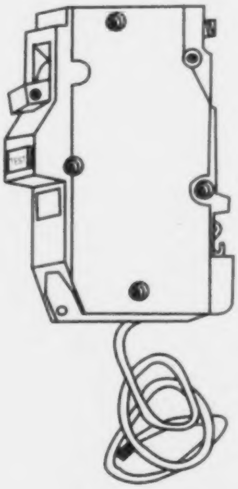
g. Switch and receptacle combination



h. Ground fault receptacle 125v, 15 amp



i. Ground fault circuit breaker

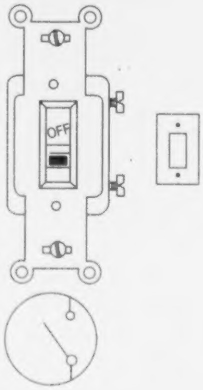


Information Sheet

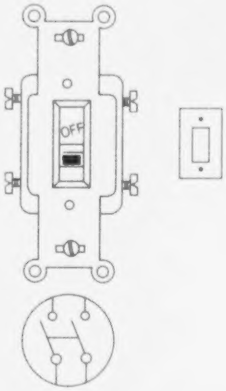
Objective 3

Common residential switch types and cover plates

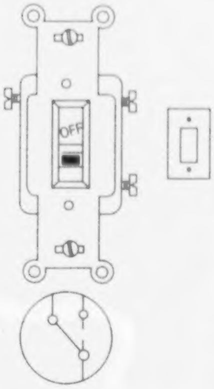
a. Single pole



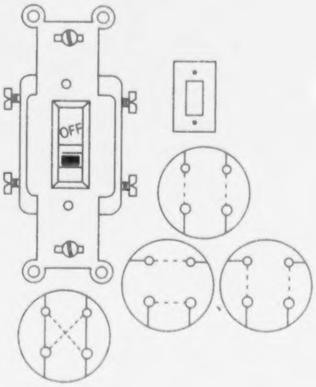
b. Double pole



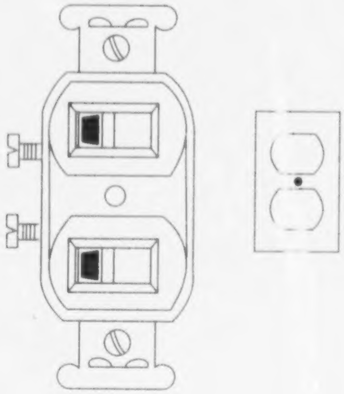
c. Three way



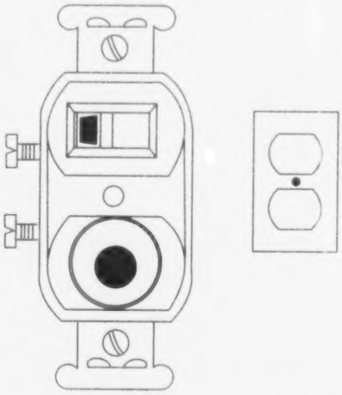
d. Four way



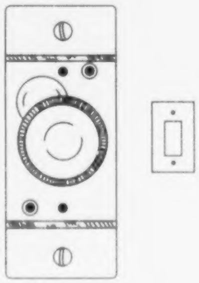
e. Duplex switches



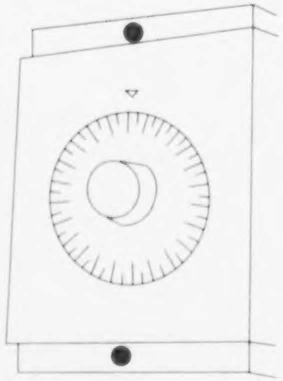
f. Switch and pilot light



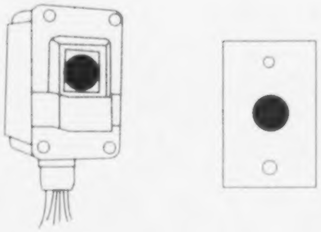
g. Dimmer



h. Timer switch



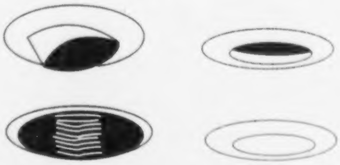
i. Photo cell



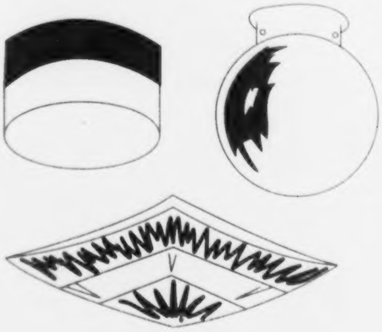
Objective 4

Common residential fixture locations and their types

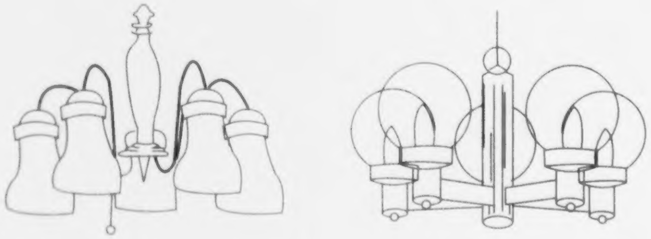
a. Recessed fixtures and trims



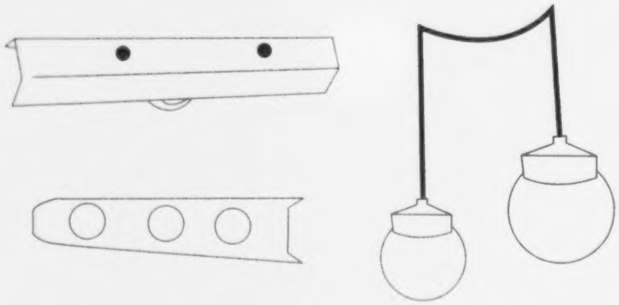
b. Bedroom or hall



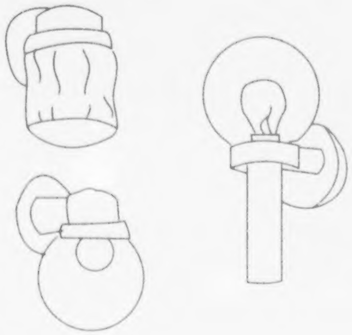
c. Dining room



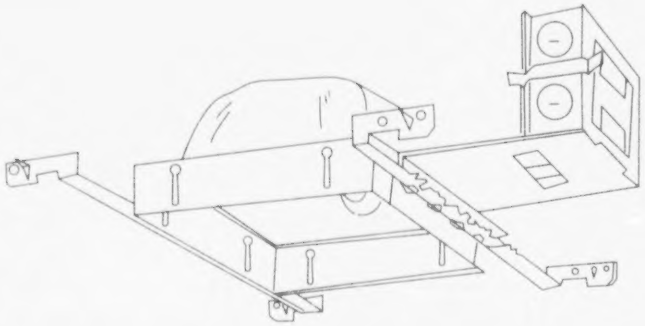
d. Bathroom



e. Outdoor entry



f. Closet



Objective 5

Appliance classifications and their descriptions

Note: *NEC* Art: 422 pertains to regulations for appliances.

a. Fixed—A current consuming device which is permanently installed such as water heaters, built-in cook-tops or ovens, and electric furnaces

b. Stationary—A current consuming device not permanently attached but, not ordinarily moved such as clothes dryers, washing machines, and free standing ranges

c. Portable—A current consuming device which is commonly moved such as blenders, mixers, toasters, and radios

d. Located on a separate circuit—A branch circuit that supplies only one (1) utilization equipment such as a range, dryer, or washing machine

e. Cord and plug connected—Connected to a branch circuit with a pigtail plug inserted into a receptacle such as portable appliances, but may include stationary or fixed-in-place appliances

Note: To comply with *NEC* requirements for cord-and-plug connections for appliances, the receptacles must be readily accessible

f. Permanently connected—Connected to the branch circuit by solid connection not readily disconnected

Objective 6

Requirements for appliance disconnect means

a. Cord and plug connected appliances—An accessible plug and receptacle shall be permitted to serve as the disconnect means.

b. Permanently connected—The branch circuit breaker shall be permitted to serve as the disconnecting means where readily accessible to the user of the appliance.

Objective 7

Grounding requirement for appliances—Appliances with exposed noncurrent carrying metal parts likely to become energized shall be grounded.

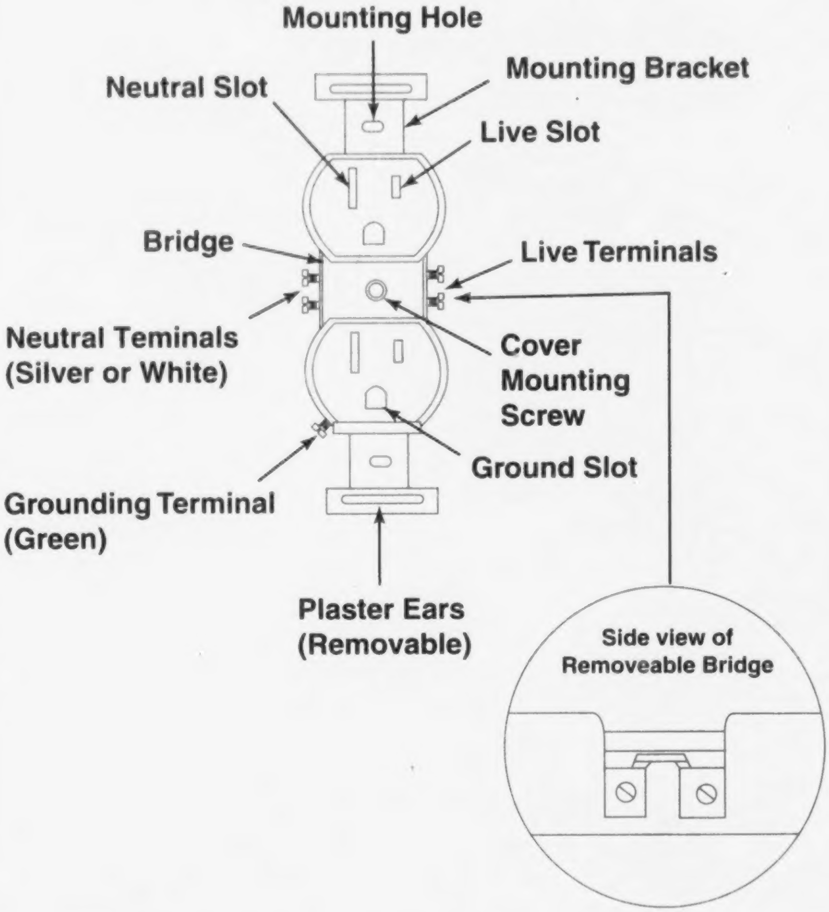
a. Cord and plug connected—Ref. *NEC* Art. 250-114 and 250-138

b. Permanently connected—Ref. *NEC* Art. 250-110 and 250-134

c. Range and dryer frames—Ref. *NEC* Art. 250-138 and 250-140

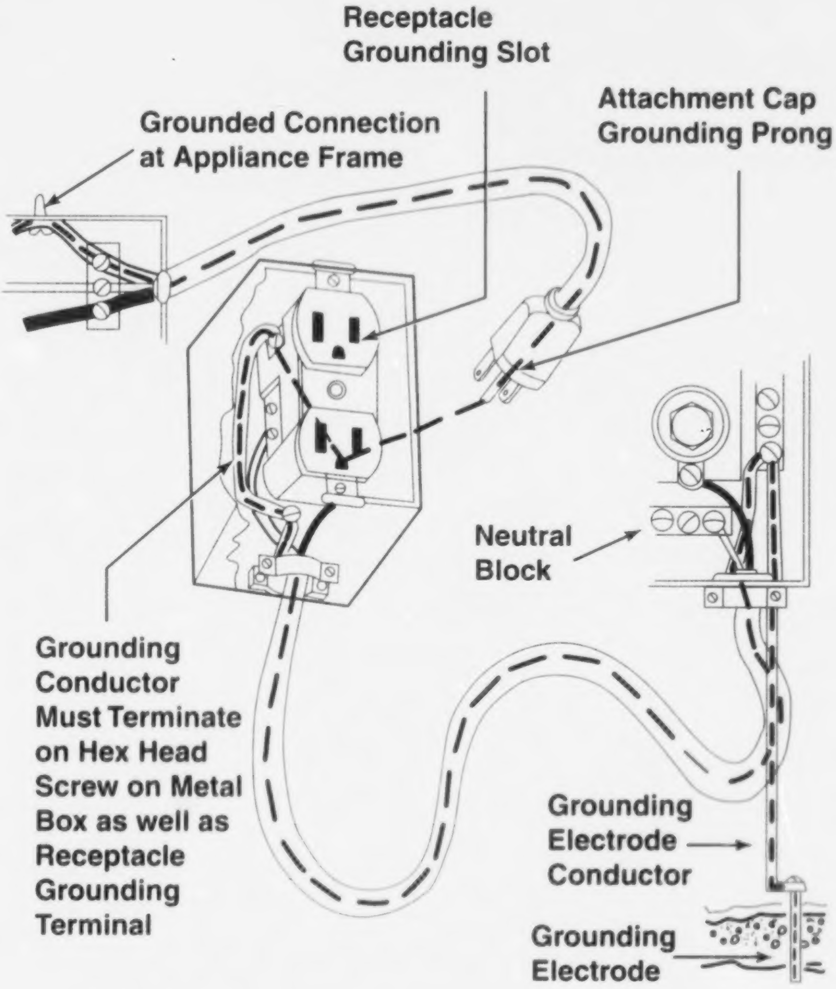
Objective 8

Parts of a duplex grounding type receptacle


Mounting Hole
Mounting Bracket
Neutral Slot
Live Slot
Bridge
Live Terminals
Neutral Teminals (Silver or White)
Cover Mounting Screw
Ground Slot
Grounding Terminal (Green)
Plaster Ears (Removable)
Side view of Removeable Bridge

Objective 9

Parts of an equipment grounding system


Receptacle Grounding Slot
Attachment Cap Grounding Prong
Grounded Connection at Appliance Frame
Neutral Block
Grounding Conductor Must Terminate on Hex Head Screw on Metal Box as well as Receptacle Grounding Terminal
Grounding Electrode Conductor
Grounding Electrode

Objective 10

Steps for panel trim out

a. Connect the grounding (bare) conductors (Ref. NEC Art. 250 Park K) to their panel location. All grounding conductors attach to the grounding bar or lug (point at which grounding electrode conductor attaches).

Note: With all conductor installation and connections inside the panel, neat and orderly forming of conductors is called for. Before conductors are routed inside the panel to a connection point, they should be straightened and preformed in the direction of travel.

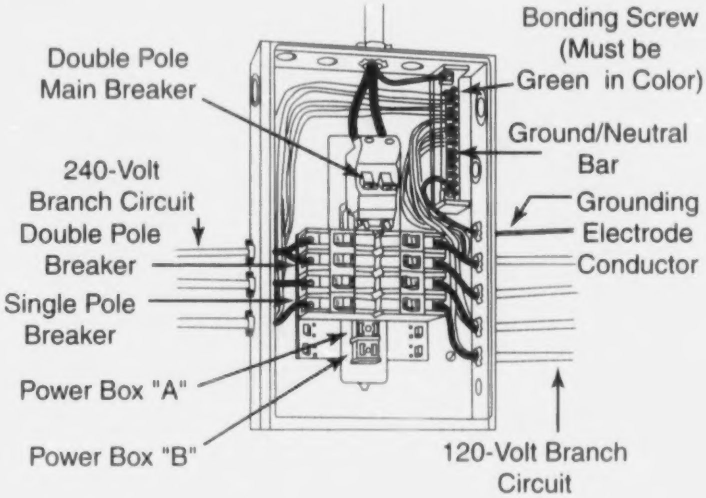
b. Connect grounded (neutral) conductors (Ref. NEC Art. 250) to the panel neutral bar.

Note: The grounded conductor is normally white but may be another color if identified. In most residential panels the grounding and grounded bar are one in the same. However, for neatness and ease of tracing conductors, these different conductors should be installed in separated positions on the bar.

c. Connect ungrounded (hot) conductors to their overcurrent protection devices (fuse holders or circuit breakers).

CAUTION: With all multiwire circuits (both "hot" wires share the same neutral) care must be taken to insure that the ungrounded conductors are connected to different bus bar phases. This will prevent neutral overload.

Note: The ungrounded conductors of a multiwire circuit must be simultaneously opened at the panel. This may be secured by connection to a 2-pole circuit breaker or two single-pole circuit breakers with a handle tie. Where fuses are used, a two-pole disconnect switch is required.


Double Pole Main Breaker
240-Volt Branch Circuit
Double Pole Breaker
Single Pole Breaker
Power Box "A"
Power Box "B"
Bonding Screw (Must be Green in Color)
Ground/Neutral Bar
Grounding Electrode Conductor
120-Volt Branch Circuit

d. Label panel in the form of a directory. This directory for circuit breaker location should be of a permanent type.

Note: Most panels provide a space for the directory inside panel cover door.

e. Energize the system with temporary power after all other circuit trim out is completed. At this time a complete check out of job should be performed.

Note: Check all circuits for proper operation, correct voltage output, and correct identification through directory.

Objective 11

Troubleshooting procedures

a. Determine symptoms of problem causing system. Consult owner about operation of system before, during, and after problem occurred.

Note: A great deal of information can be gained in this questioning—did it flicker, hum, or explode? Was anything unusual going on at the time of problem, lightning, unusual load, too many appliances plugged in, has it happened before?

b. Inspect the system

Note: The panel is the place to start since the overcurrent protection device will identify the problem circuit.

- Trace system from panel by
  - Color of conductor
  - Number of conductor
  - Using an ohmmeter

CAUTION: Always disconnect supply power from circuit to be tested before using ohmmeter. Line voltages will damage meter.

- Check conductor's condition
  - Conductor discolored from overheating
  - Conductor insulation damaged or nicked
  - Loose conductor connection at devices or splice points
- Check devices or fixtures
  - Device worn or overheated
  - Fixture worn or overheated
  - Reversed outlet polarity

Note: Lamp wattages shall not exceed manufacturer's recommendations.

c. Locate problem causing area

- Bad device or fixture
- Broken conductor
- Circuit overload

d. Repair or replace cause of problem

- Install a new device or fixture
- Rewire circuit
- Install extra circuit to compensate for overload

Objective 12

Focus Assignment—List and Price Lighting Fixtures

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Chose appropriate fixtures	______
• Listed fixtures, part numbers, and prices	______

Basic Skills

Reading Critical Thinking

Introduction

The fixtures and devices used in residential trim-out can greatly affect the total "look" of the house.

Directions

Using catalogs supplied by your instructor or internet resources, pick out ten different styles of light fixtures that would be appropriate over a large dining room table. Submit a list with part numbers and prices to your instructor.

Type of Fixture	Part Number	Price

Objective 13

Assignment Sheet 1—Troubleshoot Electrical Problems

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Identified proper troubleshooting procedures	______
• Listed steps and possible solutions to the scenarios	______

Basic Skills

Reading Writing Critical Thinking

Directions

Using the information provided in Objective 11 of the Information Sheet as a guide, list the steps you would take to troubleshoot the problems described in the following scenarios. Also include possible solutions to the scenarios.

Scenario 1:

The homeowner states that the lights in the house blink off and on, and the digital clocks need resetting daily. He also states that there's a strange smell coming from the breaker box.

Scenario 2:

The duplex receptacles serving the living room have been working for many years but now the homeowner reports that half of them are "dead".

Objective 14

Job Sheet 1—Wire a Receptacle Fed From a Lighting Outlet Through a Single Pole Switch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Boxes mounted properly	______
• Holes bored correctly	______
• Romex run properly	______
• Romex stapled	______
• Make-up correct	______
• Grounded properly	______
• Workmanship	______
• Compliance to *NEC*	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- 12-2G or 14-2G NM cable
- 12-3G or 14-3G NM cable
- Two device boxes
- Octagon box and bar hanger
  Note: Bar hangers come in various lengths.
- Light socket
- 120 volt bulb
- Staples
- Single pole switch
- Duplex grounding type receptacle
- Stud wall or work board
- 120v supply
  Note: The overcurrent protection on this supply should not exceed the conductors *NEC* ampacity rating.
- Wire connectors
- Four 16 penny nails or other fasteners as needed to secure the boxes
- Electrician's hammer
- Plain tip screwdriver
- Lineworker's pliers
- Long nose pliers
- Pocked knife
- Wire strippers
- Tool pouch

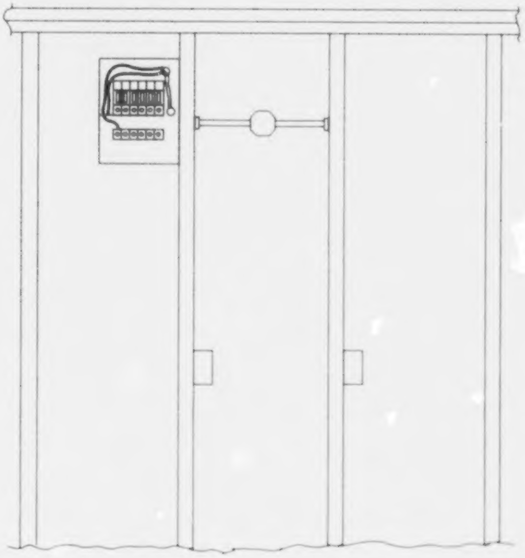
- Drill motor or brace
- 1/2" or larger wood bit
- Extension cord
- Safety glasses
- GFCI

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

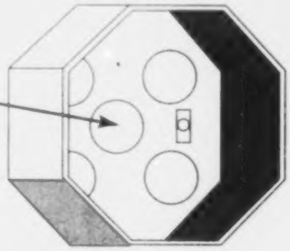
☐ 2. Mount boxes.

Figure 1



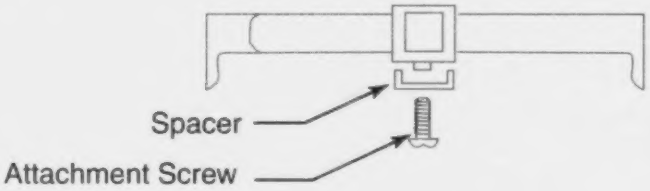
☐ a. Remove center knock-out from the back of your box.

Figure 2



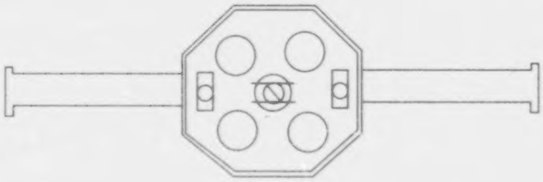
☐ b. Remove attachment screw and spacer from bar hanger.

Figure 3



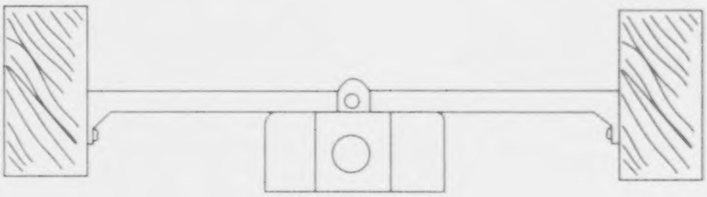
☐ c. Mount your box on the bar hanger and secure it loosely with your spacer and attachment screw.

Figure 4



☐ d. Place bar and box between stud and check set out.

Figure 5



☐ e. Nail hanger in place

☐ 3. Remove a half inch knockout from the panel.

☐ 4. Install cable connector.

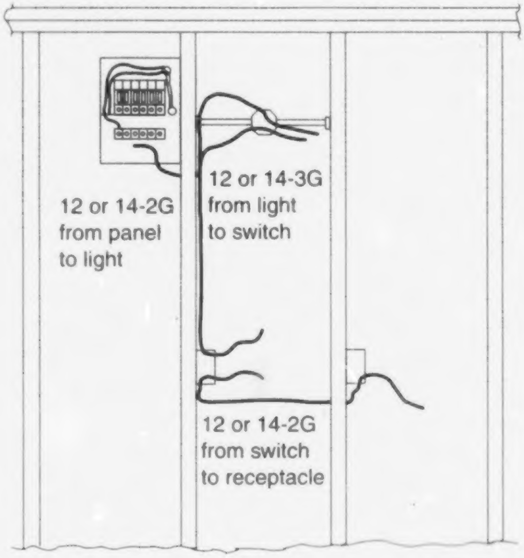
☐ 5. Bore holes for cable.

Note: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.

CAUTION: Always use a GFCI when drilling.

☐ 6. Run cable between boxes and to panel.

Figure 6


12 or 14-2G
from panel
to light
12 or 14-3G
from light
to switch
12 or 14-2G
from switch
to receptacle

Note: Leave at least 8″ extending past the surface of your device boxes, and enough to reach the top of your panel plus half the width.

☐ 7. Staple cable within 12″ of metal boxes, 6″ of nonmetallic boxes.

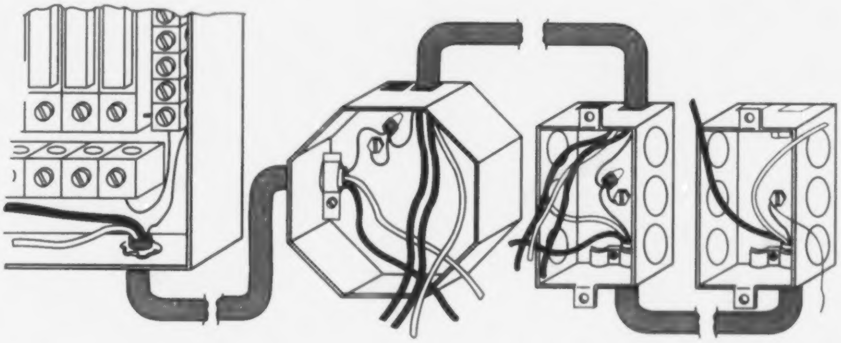
☐ 8. Secure all cable clamps and connectors.

CAUTION: Tighten them until the cable will not slip in the box; over tightening can cause an electrical short.

☐ 9. Strip cable insulation at device box and panel.

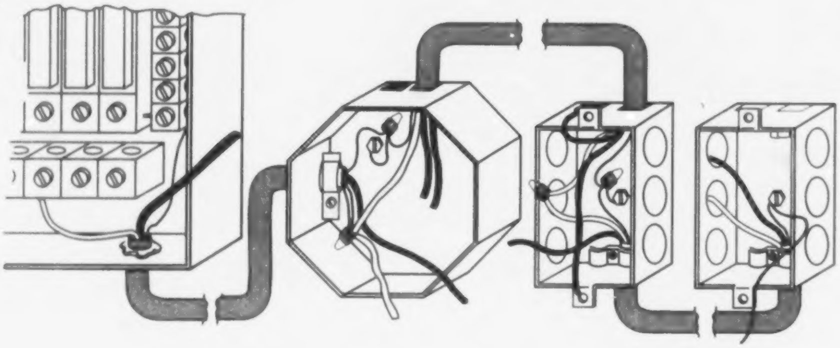
☐ 10. Connect equipment grounding conductors.

Figure 7



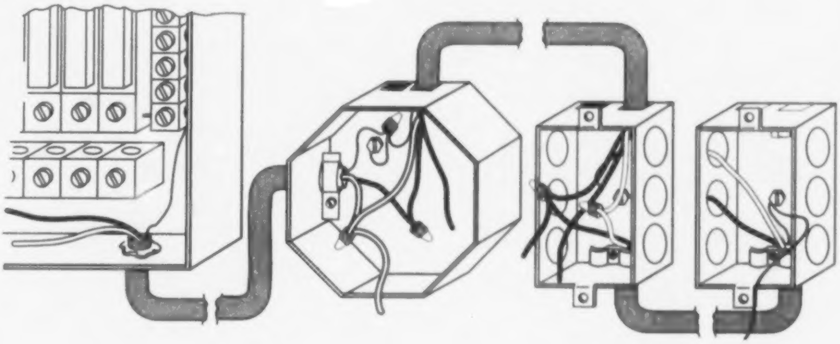
☐ 11. Make up neutral through the system.

Figure 8



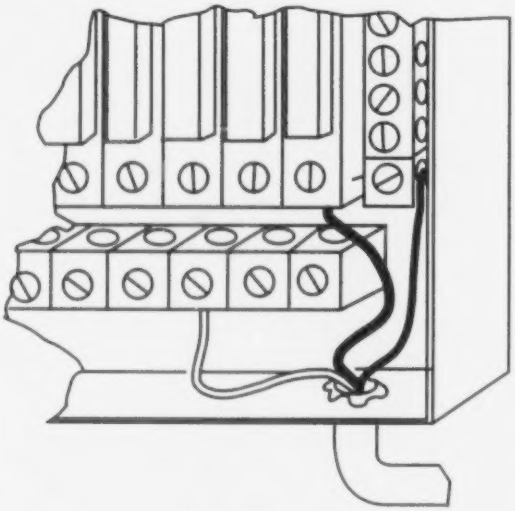
☐ 12. Make up switch, return, and feed through conductors.

Figure 9



☐ 13. Connect ungrounded conductors.

Figure 10



Note: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 14. Have your instructor evaluate this project.

☐ 15. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 15

Job Sheet 2—Wire a Switch Controlled Split-Wired Receptacle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Boxes mounted correctly	______
• Romex run properly	______
• Holes drilled correctly	______
• Romex stapled	______
• Make-ups correct	______
• Grounding correct	______
• Workmanship	______
• Compliance to *NEC*	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria. Box location and wall coverings will be according to your instructors specifications.

Tools, equipment, and materials

- 12-2G or 14-2G NM cable
- 12-3G or 14-3G NM cable
- Two device boxes

Note: Be sure boxes have an *NEC* capacity rating to accommodate the conductors you will install

- Staples
- Single pole switch
- Duplex grounding type receptacle
- Stud wall or work board
- 120v supply

Note: The overcurrent protection on this supply should not exceed the conductors *NEC* ampacity rating.

- 3/8″ cable clamp
- Wire connectors
- Four 16 penny nails or other fasteners as needed to secure the boxes
- Electrician's hammer
- Plain tip screwdriver
- Lineworker's pliers
- Needle-nose pliers
- Pocket knife

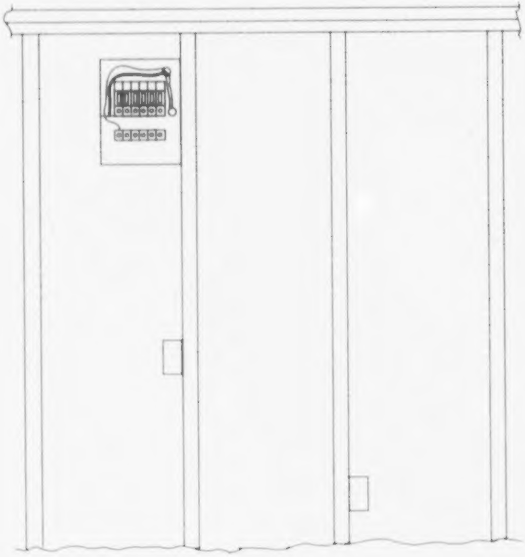
- Wire strippers
- Tool pouch
- Drill motor or brace
- $^1/_2$" or larger wood bit
- Extension cord
- Safety glasses
- GFCI

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes

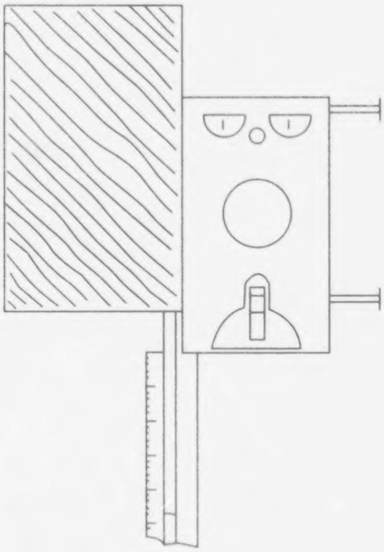
Figure 1



☐ a. Locate boxes on center with correct set out

Note: In this instance, set out is between one quarter and one half inch.

Figure 2



☐ 3. Remove a half inch knockout from the panel.

☐ 4. Install cable connector.

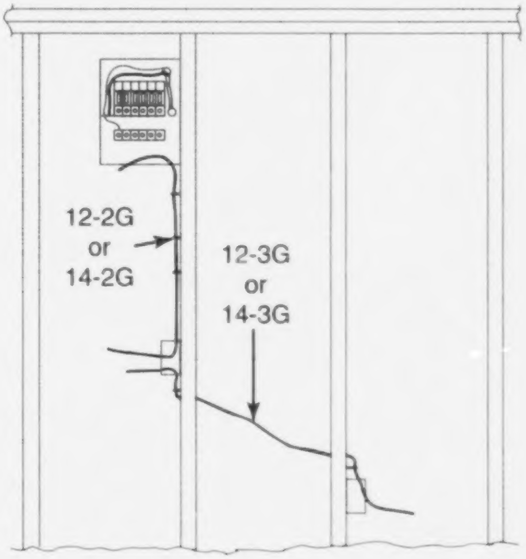
☐ 5. Bore holes for cable.

Note: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.

CAUTION: Be sure and use a GFCI when drilling.

☐ 6. Run cable between boxes and to panel.

Figure 3



Note: Leave at least 6″ extending past the surface of your device boxes, and enough to reach the top of your panel plus half the width.

☐ 7. Staple cable within 12″ of metal boxes, 6″ of all nonmetallic boxes.

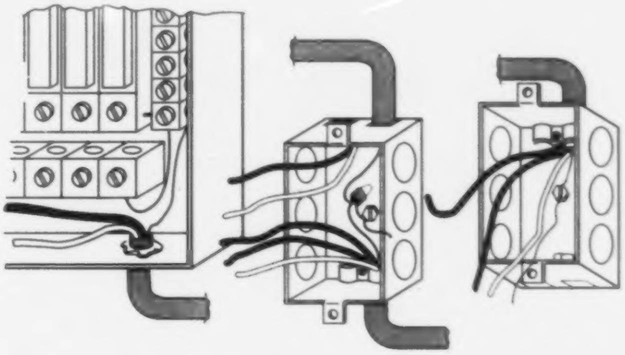
☐ 8. Secure all cable clamps and connectors.

CAUTION: Tighten them until the cable will not slip in the box; over tightening can cause an electrical short.

☐ 9. Strip cable insulation at device box and panel.

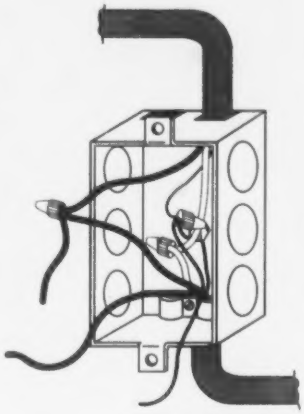
☐ 10. Connect equipment grounding conductors.

Figure 4



☐ 11. Make up switch box.

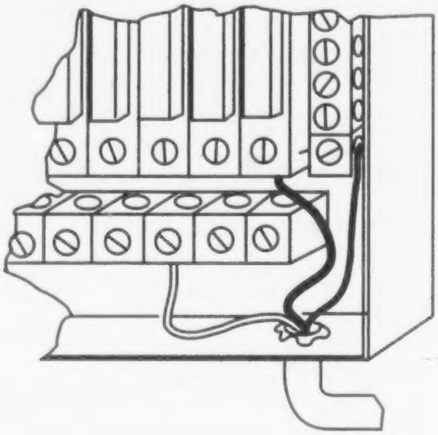
Figure 5



☐ 12. Connect grounded and ungrounded conductors.

Note: Connect grounded conductor first.

Figure 6



Note: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 13. Have your instructor evaluate this project.

☐ 14. Clean work area and put away all equipment and materials.

Evaluator's Comments: ____________________

____

____

Objective 16

Job Sheet 3—Wire a Receptacle Fed From a Lighting Outlet Through a Three-Way Switch

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Boxes mounted correctly	______
• Holes drilled properly	______
• Romex run correctly	______
• Make-ups correct	______
• Grounding connected	______
• Make-up correct	
• Workmanship	______
• Compliance to *NEC*	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- 12-2G or 14-2G NM cable
- 12-3G or 14-3G NM cable
- Three device boxes

  Note: One of the device holding boxes will have to be a 4″ square box with a plaster ring.

- Octagon box and bar hanger

  Note: Be sure boxes have an *NEC* capacity rating to accommodate the conductors to be installed.

- Staples
- Two 3-way switches
- One duplex grounding type receptacle
- Light socket
- Bar hanger

  Note: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.

- Stud wall or work board
- 120v supply

  Note: The overcurrent protection on this supply should not exceed the conductors *NEC* ampacity rating.

- $^3/_8$" cable clamp
- 120v incandescent bulb
- Wire connectors

Note: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.

- Two 16 penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain tip screwdriver
- Lineworker's pliers
- Long nose pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- $^1/_2$" or larger wood bit
- Extension cord
- Safety glasses
- GFCI

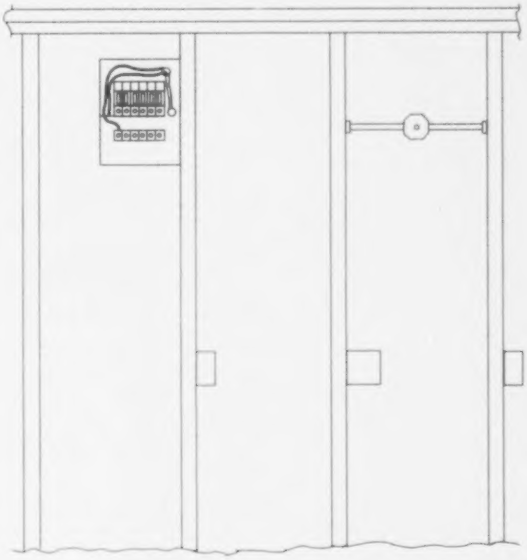
Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes.

Note: Device boxes and ceiling can be mounted at any height in this project.

Figure 1



☐ 3. Remove a half inch knockout from the panel.

☐ 4. Install cable connector.

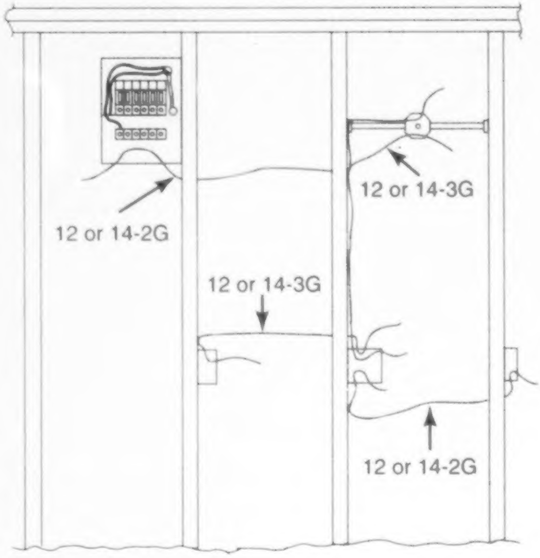
☐ 5. Bore holes for cable.

Note: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.

CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident. Be sure and use a GFCI when drilling.

☐ 6. Run cable.

Figure 2



Note: Leave at least 6″ extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus half the width.

☐ 7. Staple cable within 12″ of metal boxes, 6″ of nonmetallic boxes.

☐ 8. Secure all cable clamps and connectors.

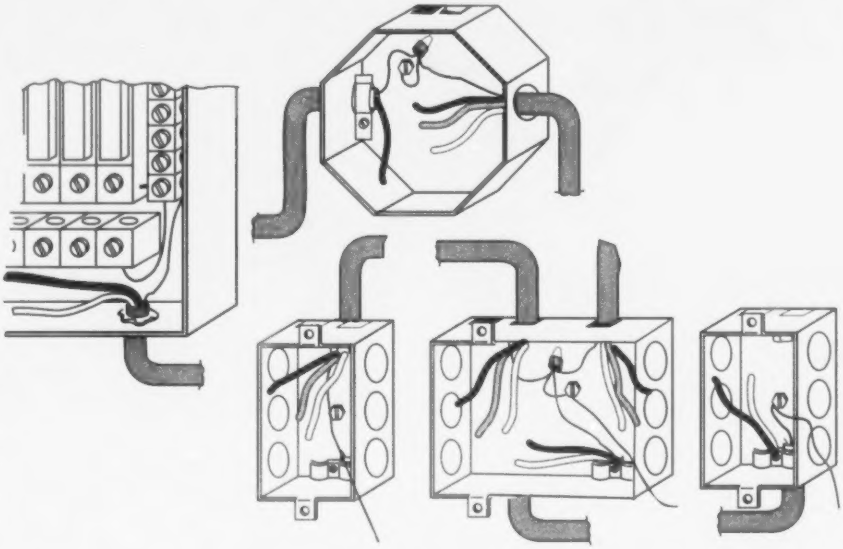
CAUTION: Tighten them until the cable will not slip in the box; over tightening can cause an electrical short.

☐ 9. Strip cable insulation.

CAUTION: Extreme care should always be used in operations involving the knife; a cut hand can cause pain and lost work time.

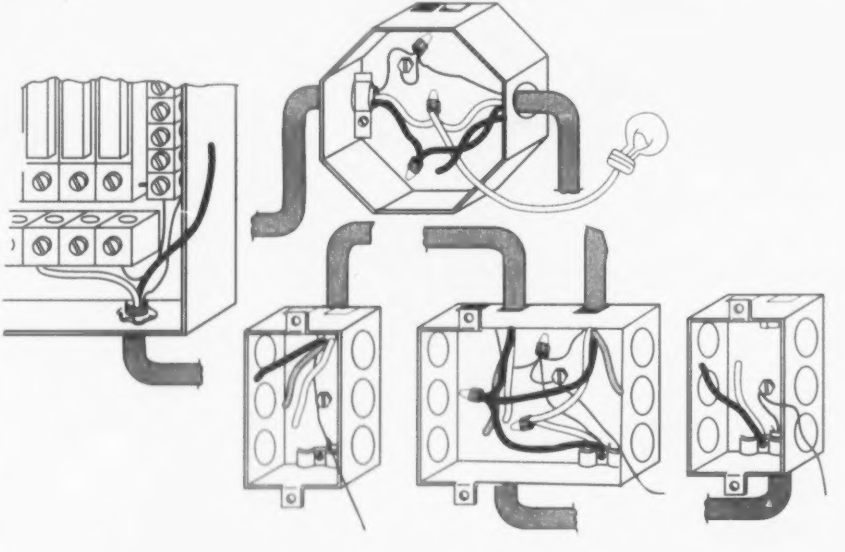
☐ 10. Connect all grounding conductors.

Figure 3



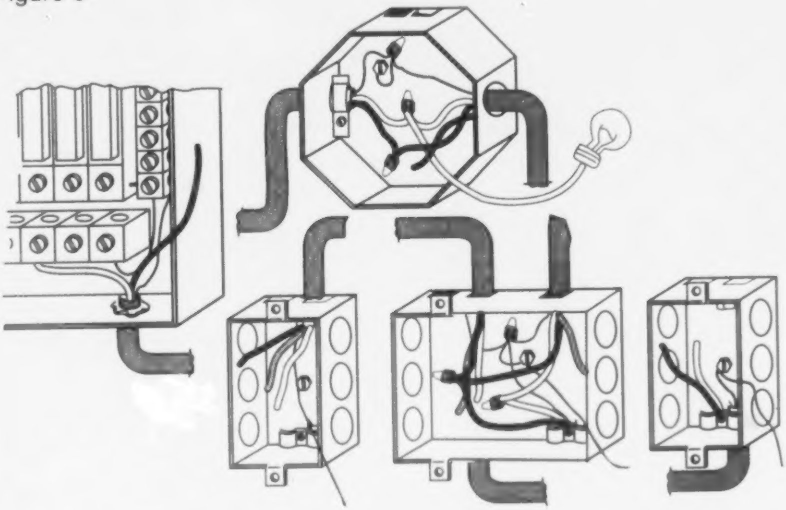
☐ 11. Connect all neutral conductors.

Figure 4



☐ 12. Connect switch leg through the system.

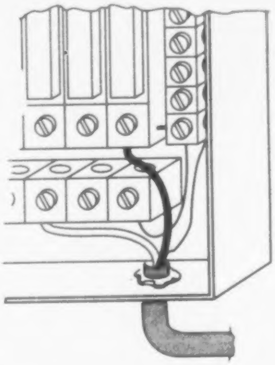
Figure 5



Note: All white conductors used as switch legs must be re-identified according to Art. 200-7(c)(2).

☐ 13. Connect ungrounded conductor to appropriate overcurrent device.

Figure 6



CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 14. Have your instructor evaluate this project.

☐ 15. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 17

Job Sheet 4—Wire a Four-Way Switching Situation with the Supply Entering the Lighting Outlet Box

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Devices installed correctly	______
• Light is controlled from either switch	______
• Workmanship	______
• Compliance to *NEC*	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- 12-2G or 14-2G NM cable
- 12-3G or 14-3G NM cable
- Three device boxes
- Octagon box

Note: Be sure boxes have an *NEC* capacity rating to accommodate the conductors to be installed.

- Staples
- Two 3-way switches
- One 4-way switch
- Light socket
- Bar hanger

Note: If a bracket octagon box is used or if this job is installed on a work board, a bar hanger will not be needed.

- Stud wall or work board
- 120v supply

Note: The overcurrent protection on this supply should not exceed the conductors *NEC* ampacity rating.

- 3/8″ cable clamp
- 120v incandescent bulb
- Wire connectors

Note: Twist on connectors will be used in this manual for illustrations. Wire connectors, pressure connectors, or solder would also be acceptable in the trade.

- Two 16 penny nails
- Two plasterboard nails
- Electrician's hammer
- Plain tip screwdriver
- Lineworker's pliers
- Long nose pliers
- Pocket knife
- Wire strippers
- Tool pouch
- Drill motor or brace
- $^1/_2$" or larger wood bit
- Extension cord
- Safety glasses
- GFCI

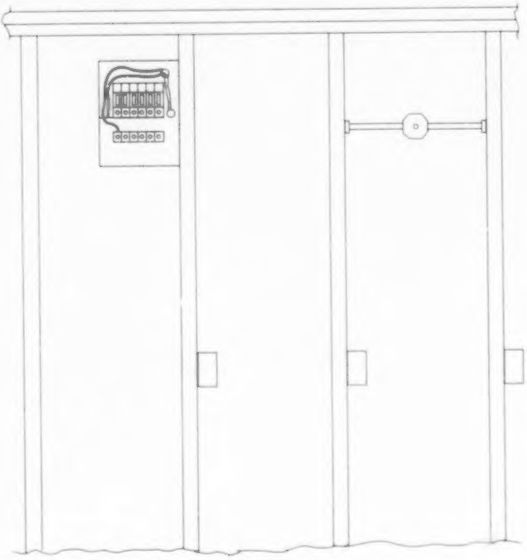
Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes.

Note: Switch box and ceiling outlet can be mounted at any height in this project.

Figure 1



☐ 3. Remove a half-inch knockout from the panel.

☐ 4. Install cable connector.

☐ 5. Plug cord into GFCI.

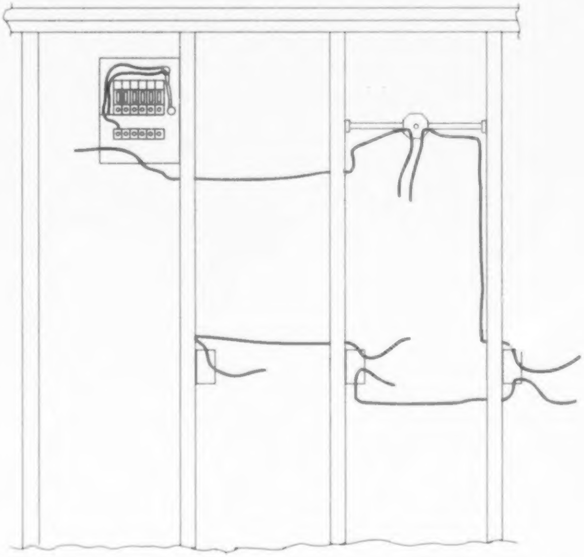
☐ 6. Bore holes for cable; holes should be large enough to safely accommodate the cables.

Note: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.

CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident.

☐ 7. Run cable.

Figure 2



Note: Leave at least 6″ extending past the surface of your device and lighting outlet boxes, and enough to reach the top of your panel plus half the width.

☐ 8. Staple cable within 12″ of metal boxes, 6″ of nonmetallic boxes.

☐ 9. Secure all cable clamps and connectors.

CAUTION: Tighten them until the cable will not slip in the box; over tightening can cause an electrical short.

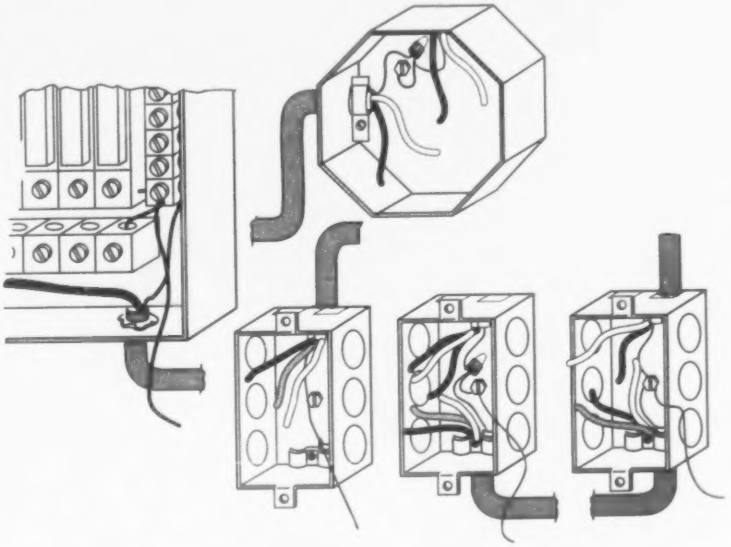
☐ 10. Strip cable insulation.

Note: Trim the cable covering to within 1/4″ of its point of entry.

CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

☐ 11. Connect all grounding conductors.

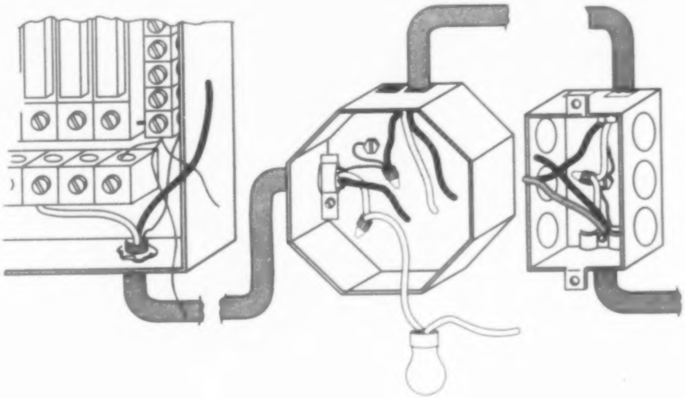
Figure 3



Note: Always leave enough conductor to make removal and reconnection easy. Notice extra bend at panel.

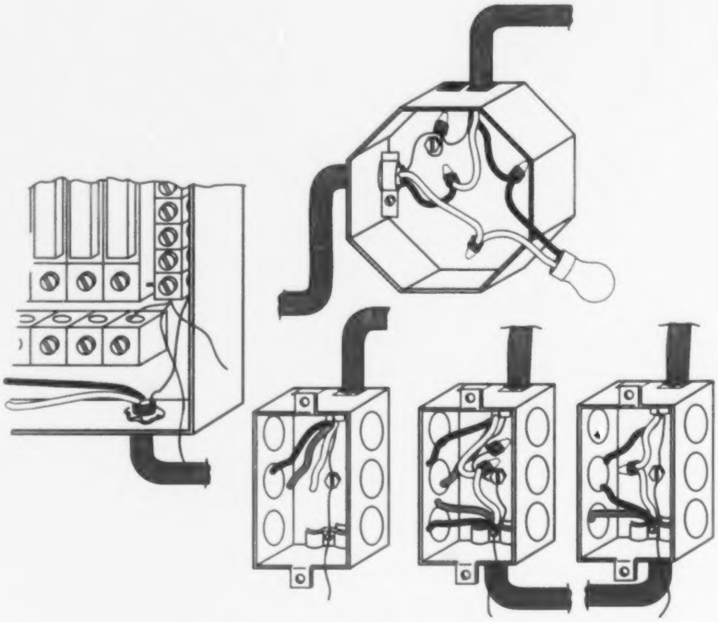
☐ 12. Connect neutral conductors.

Figure 4



☐ 13. Connect switch leg through the system.

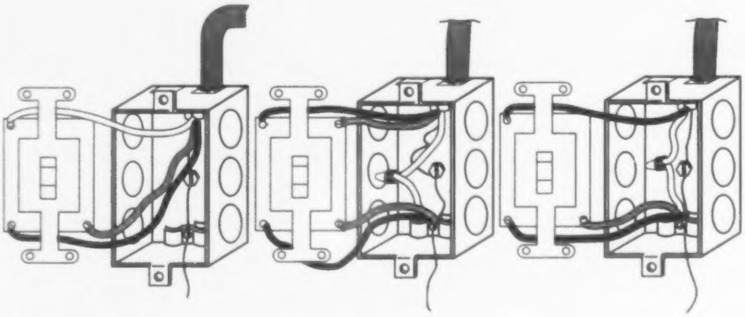
Figure 5



Note: All white conductors used as switch legs must be re-identified according to Art. 200-7(c)(2).

☐ 14. Install switches.

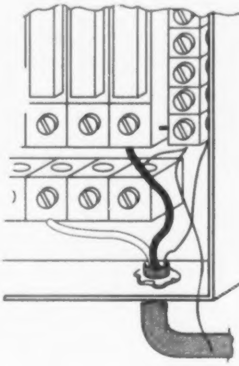
Figure 6



☐ 15. Connect return leg to socket.

☐ 16. Connect ungrounded conductor to appropriate overcurrent device.

Figure 7



CAUTION: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 17. Turn on breaker.

CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 18. Change the position of the switches in alternating movements.

Note: Be sure you can turn on or off from either switch as well as on at one and off at the other.

☐ 19. Have your instructor evaluate this project.

☐ 20. Turn off breaker.

☐ 21. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 18

Job Sheet 5—Mount a Fan Box According to Manufacturer's Recommendations

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Measurements correct	______
• Box is set for plasterboard	______
• Box is mounted correctly	______
• Workmanship	______
• Compliance to *NEC*	

Basic Skills

Reading

Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- 12-2G or 14-2G NM cable
- 12-3G or 14-3G NM cable
- One 2-gang device box
- Staples
- Two single-pole switches
- One ceiling fan with light kit
- Rule
- Pouch tools
- Nails
- Safety glasses
- Marker or pencil
- One fan box with bar hanger

Procedure

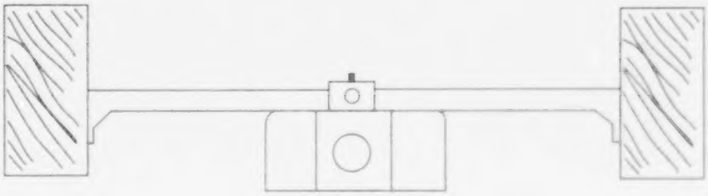
☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Find exact location where fan box will be mounted.

☐ 3. Read fan box manufacturer's instructions.

☐ 4. Carefully mount the box with hanger between ceiling joist.

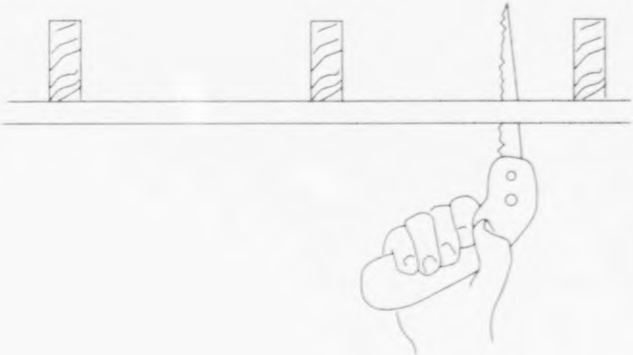
Figure 1



☐ a. Hold the fan box against the ceiling and trace the outline of the box on the ceiling with a pencil.

☐ b. Enlarge the opening with a keyhole saw if necessary.

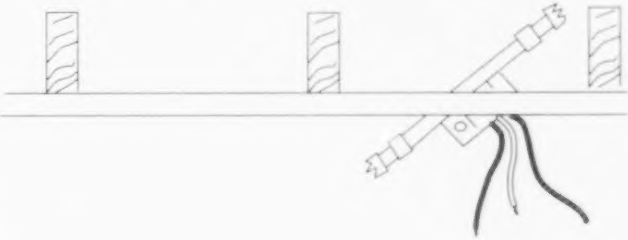
Figure 2



☐ c. Carefully mount the box with hanger between ceiling joists.

Note: Be sure box set is in accordance with the thickness of the plasterboard and NEC Art.: 370-20. Also, carefully follow the manufacturer's mounting instructions. This may require working from the attic space.

Figure 3



☐ d. Check that fan box is secure and that you have completely followed the manufacturer's instructions.

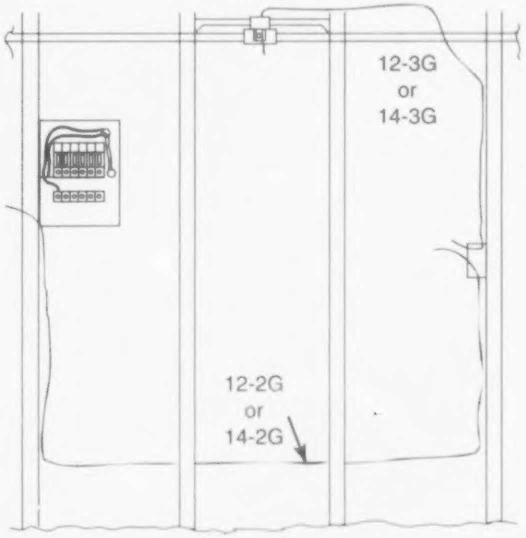
☐ 5. Mount 2-gang device box on stud wall at the proper height above floor.

☐ 6. Bore holes for cable routing.

☐ 7. Route a length of 12-2-G NMB or 14-2-G NMB from the power source to the 2-gang device box.

☐ 8. Route a length of 12-3-G NMB or 14-3-G NMB from the power source to the 2-gang device box.

Figure 4



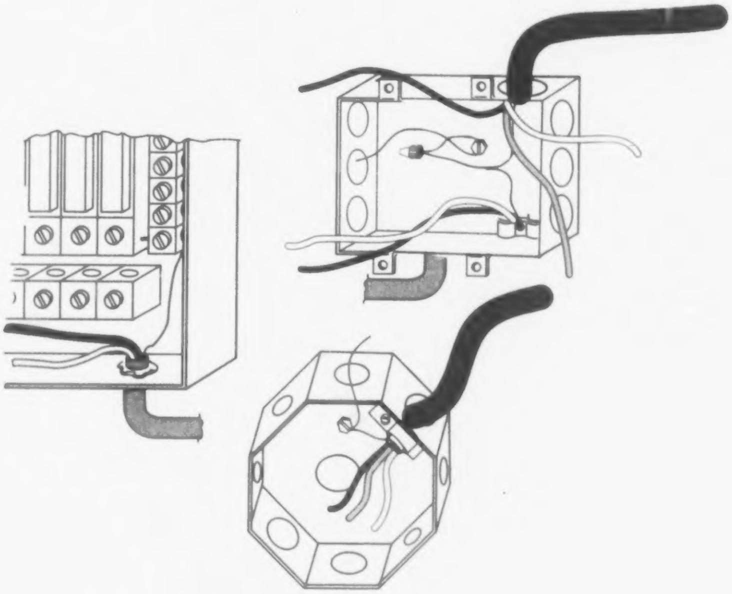
☐ 9. Staple cable within 12″ of metal boxes, 6″ of all nonmetallic boxes.

☐ 10. Secure all cable clamps and connectors.

☐ 11. Strip insulation at panel, device box, and fan box.

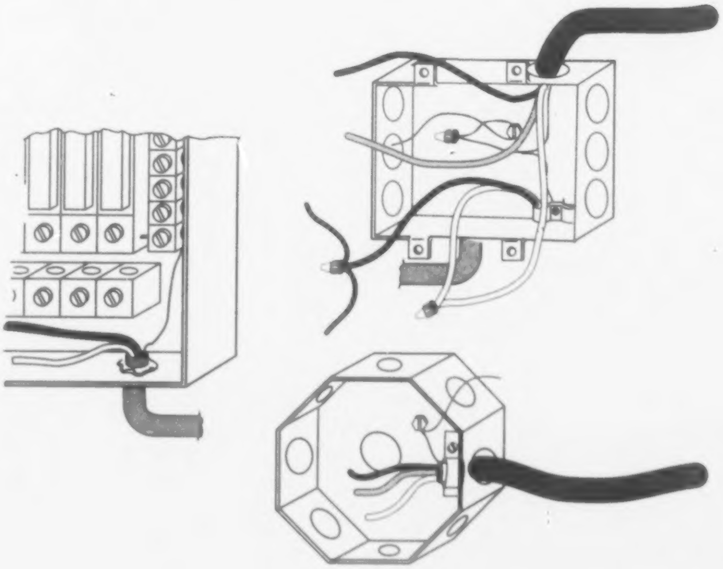
☐ 12. Connect equipment grounding conductors.

Figure 5



☐ 13. Make up boxes.

Figure 6



☐ 14. Connect grounded and ungrounded conductors.

Note: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 15. Install the switches and the fan.

☐ 16. Have your instructor evaluate this project.

☐ 17. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 19

Job Sheet 6—Install a Range or Dryer Receptacle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Device installed securely	______
• Device performs correctly when energized	______
• Proper polarity maintained	______
• Workmanship	______
• Compliance to *NEC*	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Lineworker's pliers
- Long nose pliers
- Screwdriver
- Pocket knife
- Wire strippers
- Electrician's hammer
- 10-3G or 8-3G NM cable box
- Box

Note: Check NEC Art: 370-16 for box requirements

- Electrical supply
- Staples
- 1/2″ or 3/4″ cable connector
- Stud wall or work board
- Tool pouch
- Folding rule with sliding scale or tape
- Safety glasses
- Drill motor or brace
- 1/2″ or larger wood bit
- Extension cord
- 125-250 volt, 30 or 50 amp receptacle
- GFCI

Job Sheet 6

Procedure

☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Mount box.

Note: Remember that your box set-out depends on the thickness of the wall covering to be installed. Be sure your box is rated for your conductors.

☐ 3. Remove a appropriate size knockout from the panel.

Note: Lineworker's pliers may be needed to finish removing the raised knockout.

☐ 4. Install cable connector.

☐ 5. Bore holes for cable.

Note: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.

CAUTION: Be sure and drill hole securely. A loose grip can cause an accident. Be sure and use GFCI protection.

☐ 6. Run cable.

Note: Leave at least 8″ extending past the surface of device box, and enough to reach the top of panel plus half the width.

☐ 7. Staple cable within 12″ of metal boxes, 6″ of nonmetallic boxes.

☐ 8. Secure all cable clamps and connectors.

CAUTION: Tighten them until the cable will not slip in the box; over tightening can cause an electrical short.

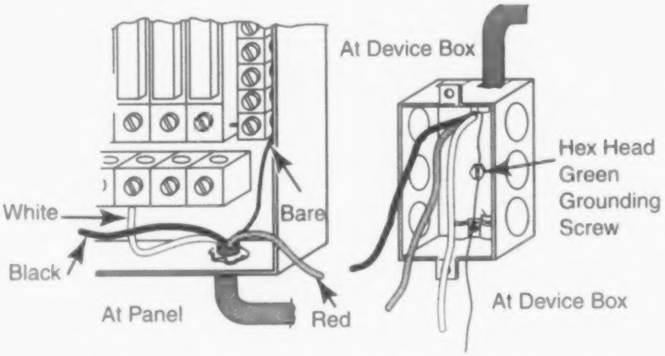
☐ 9. Strip cable insulation at device box and panel.

Note: Trim the cable covering to within 1/4″ of its point of entry.

CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

☐ 10. Connect neutral and equipment grounding conductors.

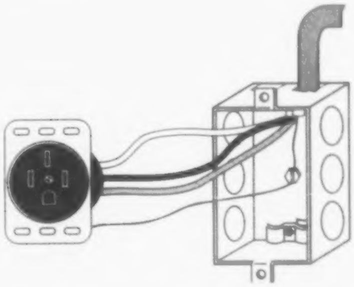
Figure 1


At Device Box
Hex Head Green Grounding Screw
White
Bare
Black
At Panel
Red
At Device Box

Note: Article 250-138 requires a fixed grounding type contact in the cord-and-plug connection for the proper grounding of the appliance frame. Also see Article 250-140.

☐ 11. Install your device.

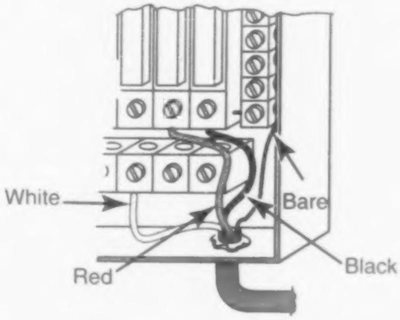
Figure 2



Note: Neutral must be insulated if fed from a subpanel. White conductor goes to terminal labeled "W" or Gr. The red and black connect to other terminals.

☐ 12. Connect ungrounded conductor to appropriate overcurrent device.

Figure 3



Note: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 13. Turn breaker on or screw fuse in.

> **CAUTION:** Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 14. Test receptacle with neon test light or voltmeter.

☐ 15. Have instructor evaluate this project.

☐ 16. Turn off breaker.

☐ 17. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 20

Job Sheet 7—Connect a Supply Cord to a Free Standing Range or Dryer

Name ____________________ Attempt Number ________

Date ____________________ Overall Rating ________

Evaluation Criteria	Rating
• Appliance operates properly when energized	______
• Workmanship	______
• Compliance to *NEC*	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Screwdriver
- Appropriate appliance cord

Note: Cord must be acceptable to the *NEC* and local code enforcing agent.

- Free standing range
- Nut driver set
- Safety glasses

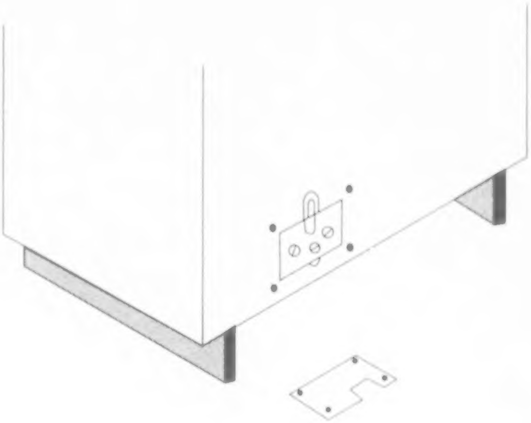
Procedure

☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Position range in best possible working position.

☐ 3. Remove appliance terminal cover plate.

Figure 1



☐ 4. Install cord securing equipment.

Note: Most range/dryer cord sets have a clamp included with the cord.

☐ 5. Connect ungrounded conductors to appropriate terminals.

☐ 6. Connect equipment grounding conductor.

Note: The frame of the range/dryer must be grounded in accordance with the *NEC* Article 250-140.

☐ 7. Check cord conductors.

Note: Conductors should be arranged so that a pull on the cord will put tension on the cord connector, not the appliance terminals.

☐ 8. Replace cover plate.

☐ 9. Plug in appliance.

☐ 10. Check appliance for correct operation.

Note: Be sure and remove all tape and packing from the oven/dryer before testing.

☐ 11. Clean work and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 21

Job Sheet 8—Install a Fixed Appliance Equipped with a Pigtail to a Branch Circuit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Appliance operates properly when energized	______
• Workmanship	______
• Compliance to *NEC*	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Box and cover

  Note: Be sure box has a capacity rating to accommodate the conductors being used.

- Fixed appliance with pigtail

  Note: Pigtail should consist of approved flexible cord or conduit with proper sized conductors for the appliance being connected.

- Connectors

  Note: The pigtail may have a connector already on it. A cable connector will probably be needed if not internal with the box.

- Two #12 x 1" MTS screws
- Wire connectors

  Note: Wire nuts, crimp sleeves, and tape or any other code approved method are acceptable.

- Screwdriver
- Pocket knife
- Wire strippers
- Safety glasses

Job Sheet 8

Procedure

Note: Be sure that the branch circuit you are working around is not energized.

☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Determine box location.

Note: Be sure and place the box within six feet of the appliance to be connected.

☐ 3. Mount the box.

Note: Be sure the box will not interfere with the installation of the appliance.

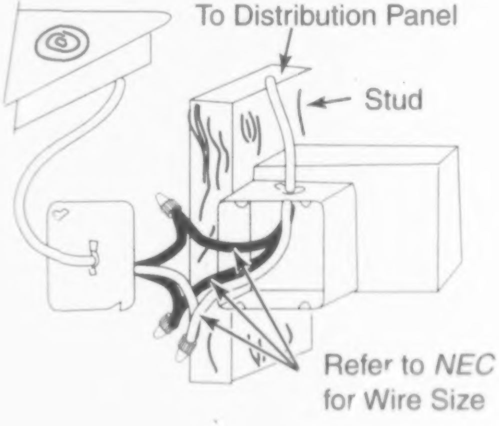
☐ 4. Install branch circuit conductors in the box.

☐ 5. Position the appliance so the pigtail will reach the box.

☐ 6. Connect appliance pigtail to box.

Figure 1

Connecting Counter Top Cooking Unit



Note: If a metal box is used, an equipment ground is required. Ref. *NEC* Article 250-134.

☐ 7. Splice appliance supply conductors to branch circuit conductors.

Note: Be sure and make mechanically secure connections.

☐ 8. Install cover plate on box.

☐ 9. Position appliance for securing.

☐ 10. Activate circuit and check appliance.

☐ 11. Rest appliance in its correct position.

Note: Make sure the pigtail is not in a bind.

☐ 12. Secure and level appliance.

☐ 13. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Objective 22

Job Sheet 9—Install a Multi-Circuit Split-Wired Duplex Grounding Type Receptacle

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Device installed securely	____
• Device performs correctly when energized	____
• Proper polarity maintained	____
• Workmanship	____
• Compliance to *NEC*	____

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Lineworker's pliers
- Long nose pliers
- Flat blade screwdriver
- Pocket knife
- Wire strippers
- Electrician's hammer
- 12-3 or 14-2G NM cable
- Device box
- Electrical supply
- Staples
- 3/8" cable connector
- Stud wall or work board
- Tool pouch
- Folding rule with sliding scale or tape
- Safety glasses
- Drill motor or brace
- 1/2" or larger wood bit
- Extension cord
- Circuit tester

Procedure

☐ 1. Gather equipment and materials and put on safety glasses.

☐ 2. Mount box.

Note: Remember that your box set-out depends on the thickness of the wall covering to be installed.

☐ 3. Remove a half inch knockout from the panel.

Note: Lineworker's pliers may be needed to finish removing the raised knockout.

☐ 4. Install cable connector.

☐ 5. Bore holes for cable.

Note: Holes should be drilled as close to the center (front to back) of a stud as possible. Holes should be drilled at least 6 inches above or below the box depending on which route is the closest.

CAUTION: Be sure and hold the drill securely. A loose grip can cause an accident. Be sure and use GFCI protection.

☐ 6. Run cable.

Note: Leave at least 8″ extending past the surface of device box, and enough to reach the top of panel plus half the width.

☐ 7. Staple cable within 12″ of the box.

☐ 8. Secure all cable clamps and connectors.

CAUTION: Tighten them until the cable will not slip in the box; over tightening can cause an electrical short.

☐ 9. Strip cable insulation at device box and panel.

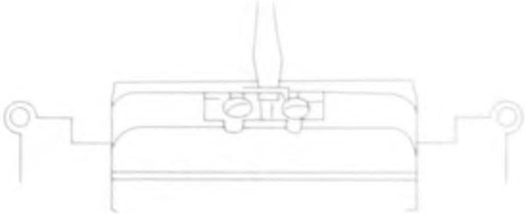
CAUTION: Extreme care should always be used in operations involving a knife; a cut hand can cause pain and lost work time.

☐ 10. Connect equipment grounding conductors and panel neutral.

Note: In a residence, all circuit neutrals and equipment grounding conductors would be connected at one time; the procedure is called panel make-up.

☐ 11. Break connecting fin from ungrounded side of receptacle.

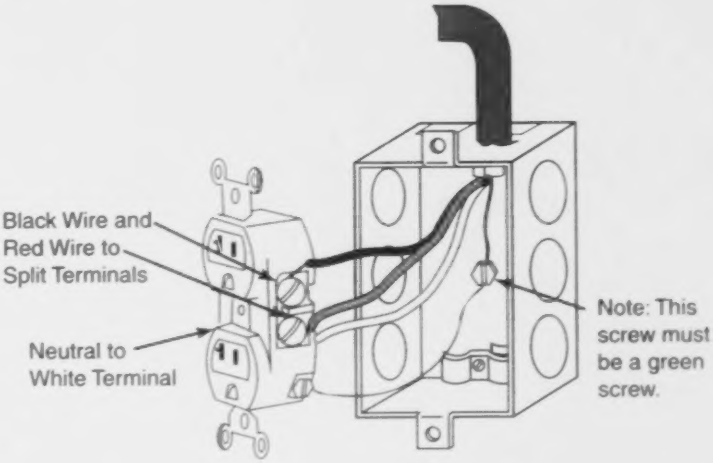
Figure 1



Note: Repeated bending motions will probably be needed to remove the connecting fin.

☐ 12. Install receptacle.

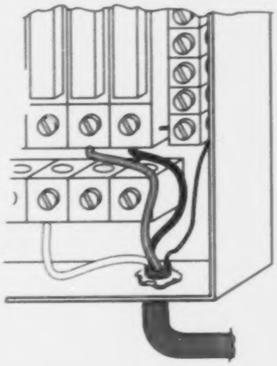
Figure 2


Black Wire and
Red Wire to
Split Terminals
Neutral to
White Terminal
Note: This
screw must
be a green
screw.

Note: A common neutral is allowed on multi-wire branch circuits where there is dual voltage potential difference between ungrounded conductors.

☐ 13. Connect ungrounded conductor to appropriate overcurrent device. Overcurrent device must be a double pole breaker or two single-pole breakers with a handle between them.

Figure 3



Note: Be sure the breaker is off or the fuse is out before connecting this conductor. Always be safety conscious.

☐ 14. Turn breaker on or screw fuse in.

CAUTION: Stand to the side of the panel when turning on the breaker. A short in the circuit could cause molten metal to fly from the panel.

☐ 15. Test receptacle with circuit tester or voltmeter.

☐ 16. Have instructor evaluate this project.

☐ 17. Turn off breaker.

☐ 18. Clean work area and put away all equipment and materials.

Evaluator's Comments: ____

____

____

Objective 23

Job Sheet 10—Install a Fusible Safety Switch for an Air-Conditioning Condenser

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Disconnect switch mounted correctly	______
• Correct voltage available when circuit energized	______
• Workmanship	______
• Compliance to *NEC*	

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Pouch tools
- Raintight fusible safety switch

  Note: Refer to *NEC* Art: 440-14

- Connecting equipment for switch

  Note: If this is a new house, a rigid metal conduit or EMT nipple should have been installed during the rough-in and should be extending just beyond the surface of the exterior wall.

- Fasteners

  Note: Anchors and screws will be required for brick or concrete; wood screws will work on wood siding.

- Safety glasses
- Pencil
- Drill motor and appropriate bit
- GFCI

Procedure

☐ 1. Gather equipment and material and put on safety glasses.

☐ 2. Mark mounting holes for switch.

Note: Remember the switch must be within sight of the unit and readily accessible. Check the applicable code requirements of *NEC* Art: 440-14 and 110-16.

☐ 3. Connect supply raceway or connector to switch.

Note: The following items are three possible rough-in techniques that could be encountered.

- Cable only visible
  - — Situate cable so not in a bind.
  - — Install a seal tight clamp on the cable.
  - — Connect cable to box.

    Note: You may have to chisel around the cable to allow the connector freedom.
- Rigid conduit with threads
  - — Adjust conduit so appropriate amount extends inside the box.

    Note: There should be enough to install a locknut and a bushing.
  - — Install back up locknut.
  - — Install interior locknut and bushing.
- EMT
  - — Put a raintight connector on EMT.
  - — Adjust conduit so switch fits flat against wall.

☐ 4. Secure switch to the wall.

Note: If holes need to be drilled be sure and use GFCI.

☐ 5. Connect grounded conductors.

Note: If a bar or lug is not supplied you can mount on a lug.

☐ 6. Connect ungrounded conductors.

☐ 7. Activate circuit.

☐ 8. Test across and between line lugs.

☐ 9. Close cover.

☐ 10. Clean work area and put away all equipment and materials.

Evaluator's Comments: ______________________________

____

____

Unit Contents

Student Components

Student Page

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Information Sheet 5–5

Focus Assignment

List Licensing Requirements for Low Voltage Wiring Systems 5–23

Assignment Sheets

1—List Uses of Low Voltage Cable 5–25
2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors 5–27

Job Sheets

1—Wire a Two-Button Chime Circuit 5–29
2—Wire Two Interconnecting Telephone Wall Jacks 5–35
3—Wire Two Interconnecting Smoke Detectors 5–39

Objective Sheet

Unit Objective

After completing this unit, the student should be able to install low voltage wiring systems. The student should demonstrate these competencies by completing the focus assignment, assignment sheets, and job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to low voltage wiring circuits with their correct definitions.
2. Select true statements concerning requirements of low voltage lighting systems.
3. Identify the parts of a low voltage lighting system.
4. Describe the process that takes place during a low voltage lighting circuit off/on cycle.
5. Complete a drawing of a front and rear door bell circuit.
6. Complete a thermostat drawing of the manual fan switching circuit to indicate the current flow path through the fan control switch and fan relay.
7. Complete a thermostat drawing to indicate the current flow path with the thermostat system switch in the cool position and the fan switch on auto.
8. Complete a thermostat drawing to indicate the current flow path with the thermostat system switch in the heat position and the fan switch on auto.
9. Complete statements about anticipator circuits on low voltage thermostats.
10. Select true statements concerning communication circuits.
11. Complete statements about smoke and fire alarm systems.
12. Select true statements about the operation of a garage door opener.
13. List licensing requirements for low voltage wiring systems. (Focus Assignment)
14. List uses of low voltage cables. (Assignment Sheet 1)
15. Draw a wiring diagram indicating the proper connections for a single smoke detector and interconnecting smoke detectors. (Assignment Sheet 2)
16. Wire a two-button chime circuit. (Job Sheet 1)
17. Wire two interconnecting telephone wall jacks. (Job Sheet 2)
18. Wire two interconnecting smoke detectors (Job Sheet 3)

Information Sheet

Objective 1

Terms and definitions

a. **Coaxial cable**—Conductor used for carrying communication signals

b. **Heat detectors**—A fire warning device commonly used in a residence; available in two types: fixed or rate-of-rise temperature detectors

c. **Momentary contact switch**—A switch that is closed or opened only while the operator touches it

d. **POTS (Plain Old Telephone Service)**—Old system of residential wiring using a quad wire conductor consisting of two pair of wire loosely twisted in a jacket.

e. **Pull-push solenoid**—Solenoid with two electromagnetic circuits that will pull or push a plunger depending on which magnet has voltage applied to it

f. **Relay**—Electromagnetic device for remote or automatic control

g. **Remote control lighting system**—Lighting system consisting of low voltage cable, low voltage relays, low voltage switches, and a transformer(s) that enable lighting circuits to be controlled by low voltage wiring circuits

h. **Ring**—Telephone conductor that is connected to the negative terminal from the telephone company

i. **Signaling circuit**—Any electric circuit that energizes signaling equipment

j. **Smoke detector**—A fire warning device commonly used in a residence; available in two types: photoelectric or ionization

k. **Solenoid**—Electromagnetic cylinder that moves an iron plunger when current is applied

l. **Telephone system**—A personal communication system installed in the home to provide outside conversation with the world

m. **Thermostat**—A device that senses temperature variations from a set point and, in turn, acts to control a circuit

n. **Tip**—Telephone conductor that is connected to the positive terminal from the telephone company

o. **Transformer**—An electrical device used to step up or step down a primary voltage to a desired secondary voltage

Information Sheet

Objective 2

Requirements of a low voltage landscape lighting system

Note: *NEC* Article 411 covers low-voltage exterior (landscape) lighting installations of systems operating at 30 volts or less.

a. Cannot be installed within 10′ of pools, spas, fountains, or similar locations, except as permitted by *NEC* Article 680.

b. Cannot be installed where concealed in, or extended through a building wall.

c. Lighting systems shall be listed for low voltage purposes.

d. Installed only on a 20 amp or less branch circuit.

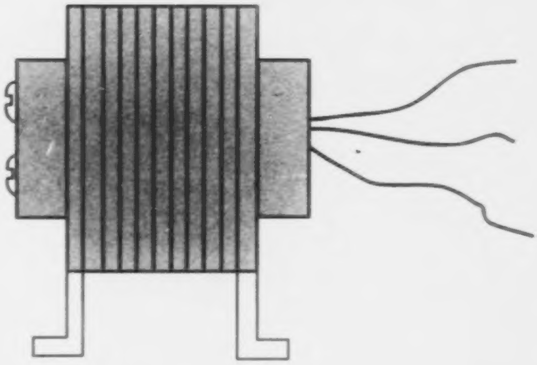
Objective 3

Parts of a low voltage remote control lighting system

a. Transformer

- Used to transform voltage from 120 volts to 24 volts.

Figure 1



b. Low voltage relay

- Uses a 24 volt control (coil) voltage to operate 120 volt lighting circuits.

Figure 2

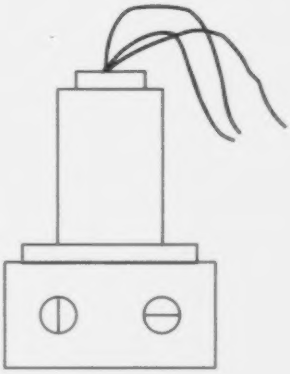
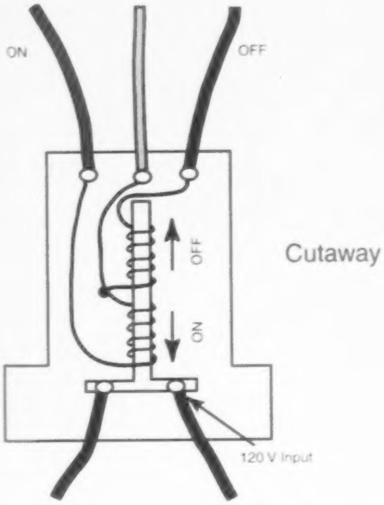


Figure 3


ON
OFF
OFF
ON
Cutaway
120 V Input

c. Low voltage remote control lighting switches.

- Special switches that are normally open, single pole, double-throw, momentary, switches.

Figure 4

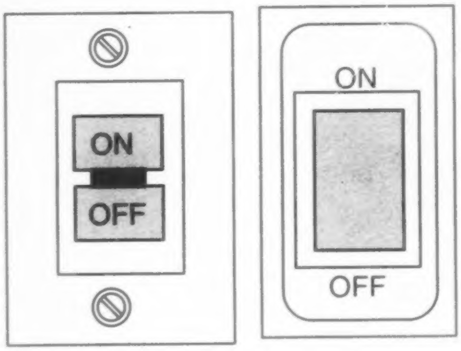
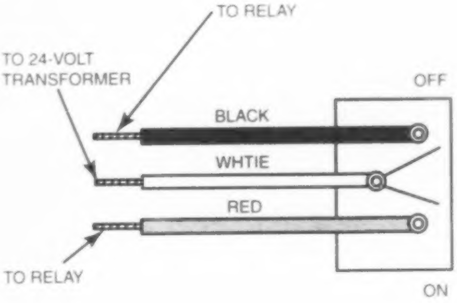

ON
OFF
ON
OFF

Figure 5


TO RELAY
TO 24-VOLT TRANSFORMER
OFF
BLACK
WHTIE
RED
TO RELAY
ON

d. Low voltage cable (class 2)

- 20 AWG conductors with 3, 4, 5, 22, etc. number of conductors.

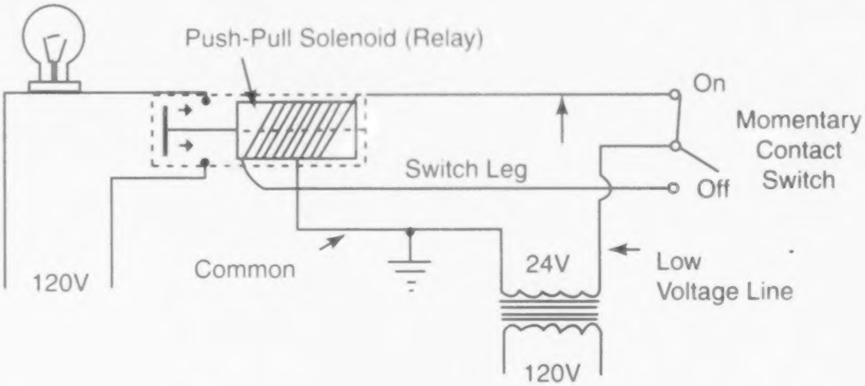
Figure 6

Objective 4

Low voltage lighting circuit off/on cycle (Figure 7-9)

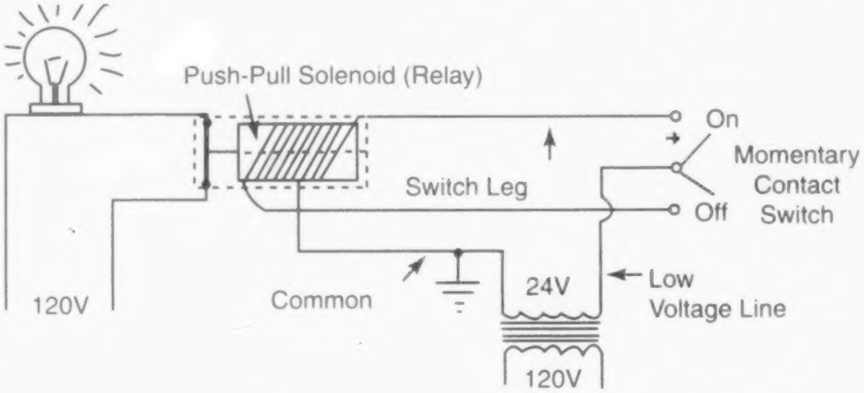
a. "On" switch is pushed.

Figure 7


Push-Pull Solenoid (Relay)
On
Momentary
Contact
Switch
Switch Leg
Off
120V
Common
24V
Low
Voltage Line
120V

- Circuit is completed to closing movement of solenoid in relay. (Figure 8).
- Core is moved and circuit is completed.

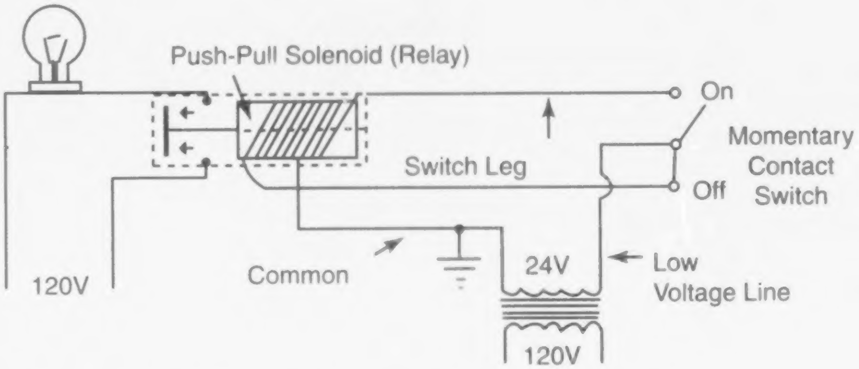
Figure 8


Push-Pull Solenoid (Relay)
On
Momentary
Contact
Switch
Switch Leg
Off
120V
Common
24V
Low
Voltage Line
120V

b. "Off" switch is pushed.

- Circuit is completed to opening movement of solenoid in relay. (Figure 9)
- Core is moved and circuit is opened.

Figure 9


Push-Pull Solenoid (Relay)
On
Momentary
Contact
Switch
Switch Leg
Off
120V
Common
24V
Low
Voltage Line
120V

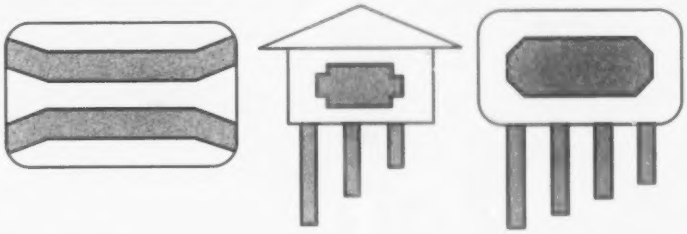
Objective 5

Components and operation of a door bell chime circuit

a. Components

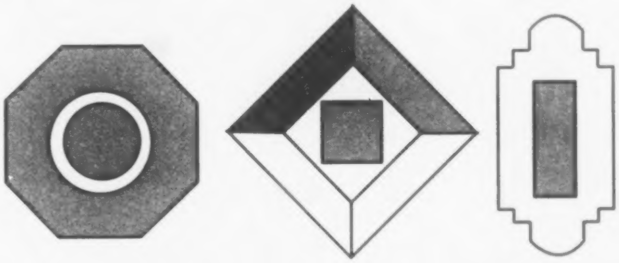
- Door chimes
  - — Available in several different notes (1, 2, 4, 8, etc.) and tones.

Figure 10-12



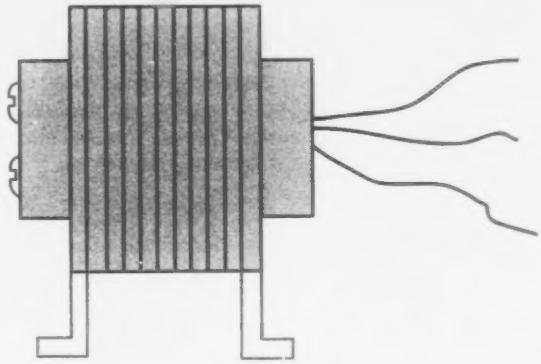
- Push buttons
  - — Available in several decorative styles

Figure 13-15



- Chime transformer
  - — Used to transform 120 volts down to 10 to 20 volts (voltage depending on the chime.)

Figure 16

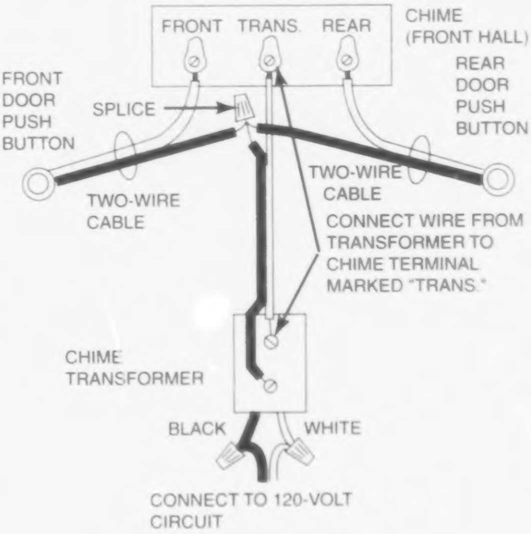


- Bell wire (class 2)
  - — Used to connect the low voltage wiring of a door bell circuit. Consists of 18 AWG gauge conductors with 3 or 5 conductors usually used on circuits 30 volts or less.

Figure 17

b. Operation of a front and rear door bell circuit

Figure 18


FRONT
TRANS.
REAR
CHIME (FRONT HALL)
FRONT DOOR PUSH BUTTON
SPLICE
REAR DOOR PUSH BUTTON
TWO-WIRE CABLE
TWO-WIRE CABLE
CONNECT WIRE FROM TRANSFORMER TO CHIME TERMINAL MARKED "TRANS."
CHIME TRANSFORMER
BLACK
WHITE
CONNECT TO 120-VOLT CIRCUIT

Objective 6

Manual fan switching circuit

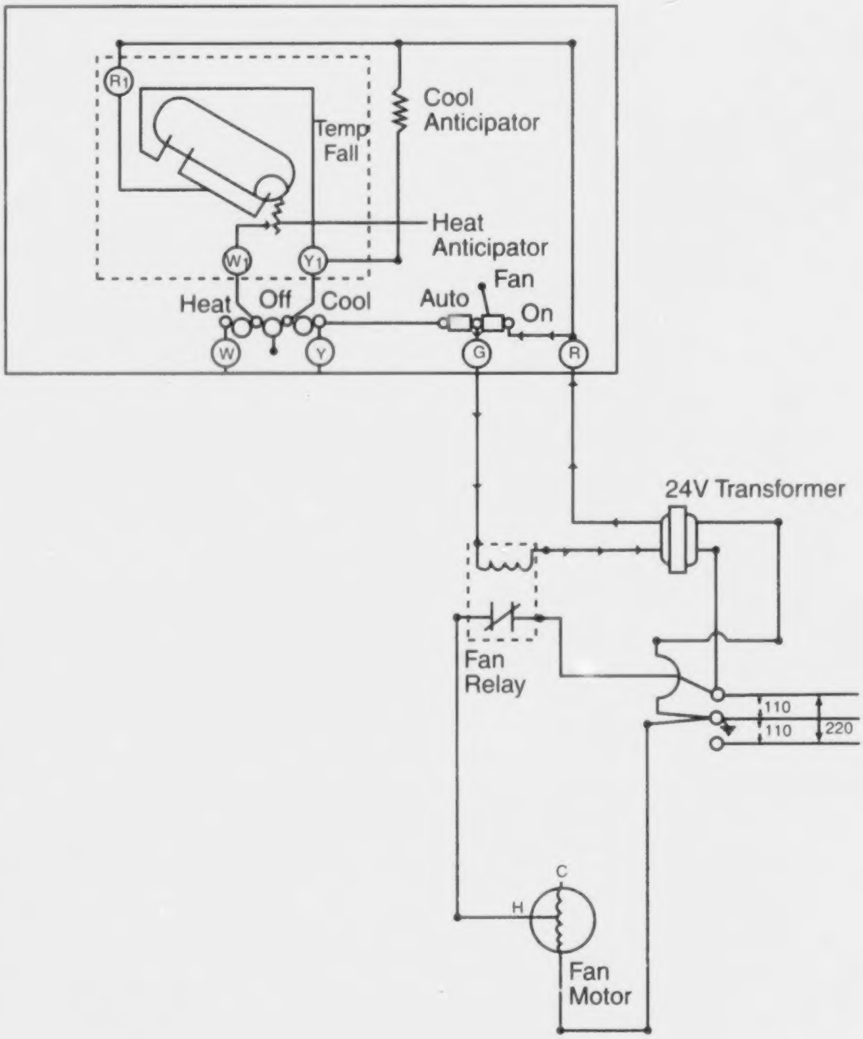
a. Current from transformer goes to fan control switch.

b. Closed switch directs current to fan relay control coil.

Note: This closes normally open contacts, and the fan motor receives line voltage and runs.

c. Common conductor returns current to transformer.

Figure 19


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Fan Relay
110
110
220
C
H
Fan Motor

Objective 7

Thermostat system switch in cool position, fan switch on auto (Figures 20 & 21)

a. Current from transformer goes to mercury bulb switch.

b. From mercury switch current goes to the system switch.

c. Current splits at the system switch.

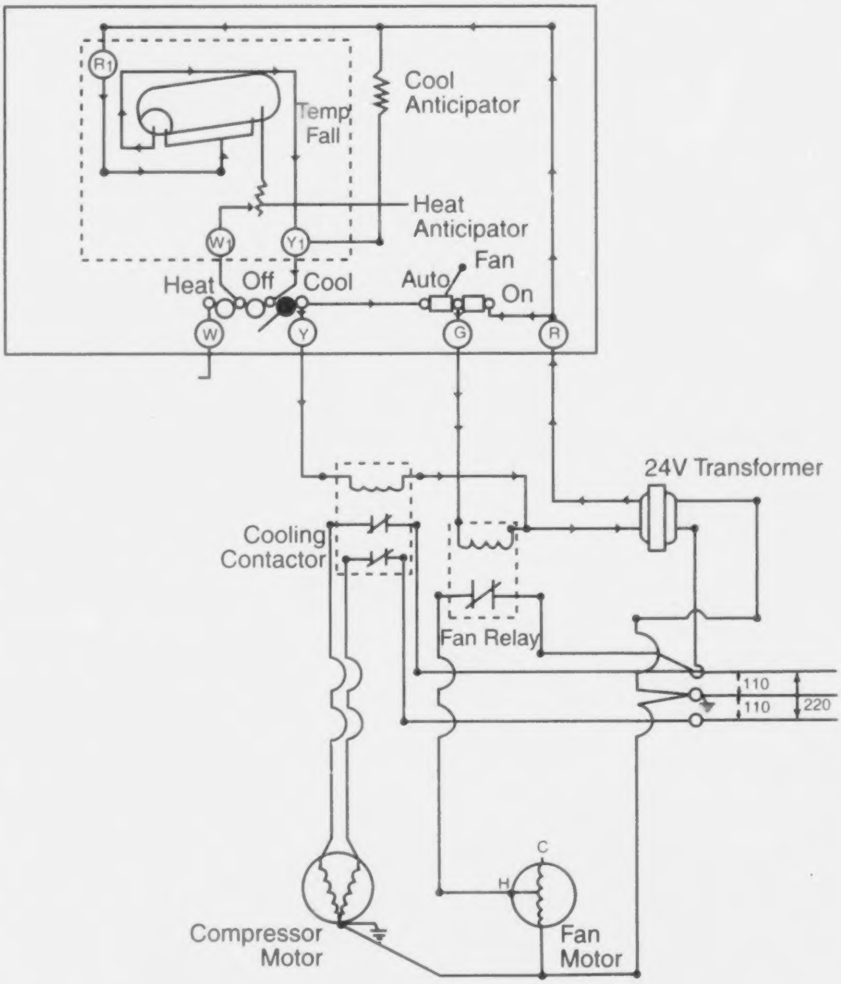
- One split goes to fan switch.

  Note: Follow the arrow heads.

  - Through closed automatic contacts
  - To fan relay control coil

    Note: This closes normally open relay contacts and starts fan motor.
  - Back to transformer

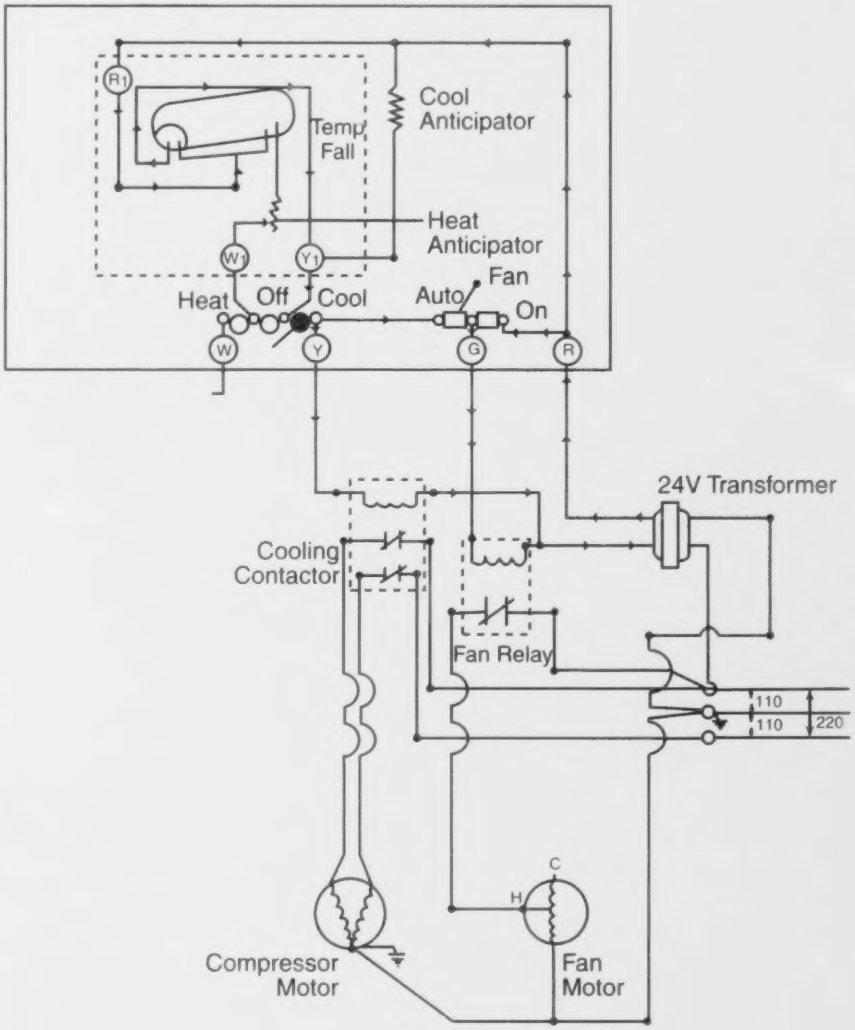
Figure 20


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

- One split goes to the cooling contactor.
  - — Through cooling contactor coil

    Note: This closes normally open contacts and compressor starts.
  - — Back to transformer

Figure 21


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Heat
Off
Cool
Auto
Fan
On
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
C
H
Compressor Motor
Fan Motor

Objective 8

System switch in heat position

a. Current from transformer goes to mercury bulb switch,

b. Through mercury bulb switch to system switch,

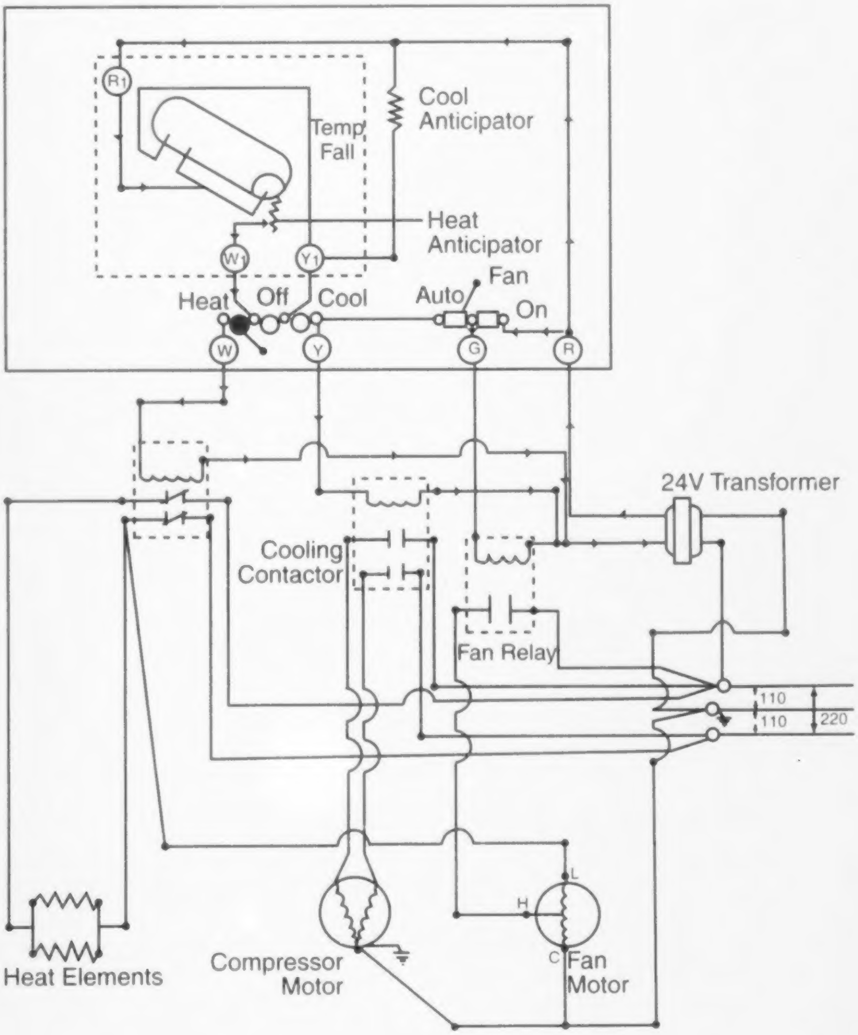
c. Through closed contacts of heat circuit,

d. To heating contactor or control valve coil, and

Note: This closes normally open relay contacts and energizes elements and low-speed fan control. On gas models, a plenum switch energizes the fan motor.

e. Back to transformer.

Figure 22


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Auto
On
Heat
Off
Cool
W
Y
G
R
24V Transformer
Cooling Contactor
Fan Relay
110
110
220
L
H
C
Heat Elements
Compressor Motor
Fan Motor

Objective 9

Anticipator circuits on low voltage thermostats

a. Heat and cool anticipators are installed to compensate for bimetallic lag.

b. Cool anticipator

Note: These are usually fixed resistors.

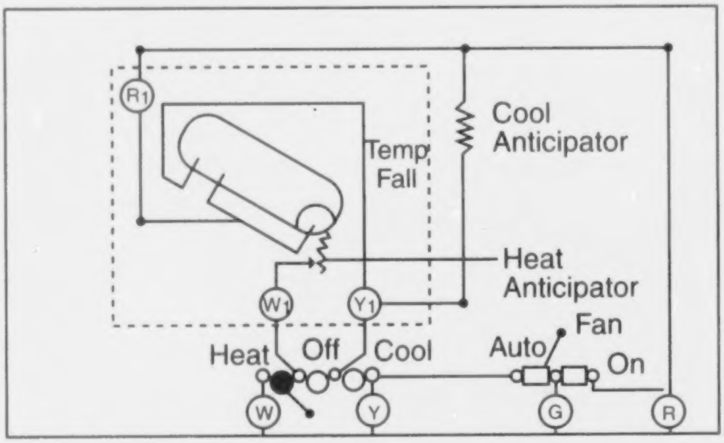
- It is wired parallel to mercury switch.
- Current draw through the resistor causes heat.
- Heat causes bimetal to tilt bulb and close circuit before room temperature actually reaches "on" temperature setting.

c. Heat anticipator

Note: These are usually variable resistors.

- It is wired in series with mercury switch.
- Current draw through switch causes heat.
- Heat causes bimetal to tilt bulb and open circuit before room temperature reaches desired room setting.

Figure 23


R1
Temp Fall
Cool Anticipator
Heat Anticipator
W1
Y1
Fan
Heat
Off
Cool
Auto
On
W
Y
G
R

Objective 10

Communication circuits and their characteristics

Note: All equipment must be UL listed.

a. Telephone

- The point where the local telephone's wiring ends and the home owner's interior wiring begins is called the "demarcation point."
- The telephone wiring inside the home must comply to the rules in Article 800 of the *NEC*.

  Note: In order to provide standards for telecommunication wiring, the Telecommunications Industry Association (TIA) has established several specifications. For residential installations, TIA-570 *Residential and Light Commercial Wiring Standard* is the document for reference.

- The recommended wire for new residential construction is category 3, 4 pair telecommunications wire. 2 pair (quad or POTS) wire will be found in almost all older residential construction.
- The common terms for telephone cable is: two pair—4 conductors, three pair—6 conductors, four pair—8 conductors, etc.
- Common color coding of 4 pair telecommunications wire

Figure 24

Standard 4 Pair Color Codes

Pair 1	**Tip**	**White/Blue**
	Ring	**Blue/White**
Pair 2	**Tip**	**White/Orange**
	Ring	**Orange/White**
Pair 3	**Tip**	**White/Green**
	Ring	**Green/White**
Pair 4	**Tip**	**White/Brown**
	Ring	**Brown/White**

Cat 3, 4 Pair Telecom Wire

Note: The polarity of each of the pairs is identified as follows: Less color is tip, more color is ring. The colors are applied with bands of white. If the band of white is larger than the exposed base color, it is tip. If the white band is small compared to exposed base color, it is ring.

- Common color coding of 2 pair (quad wire) telecommunications wire

Figure 25

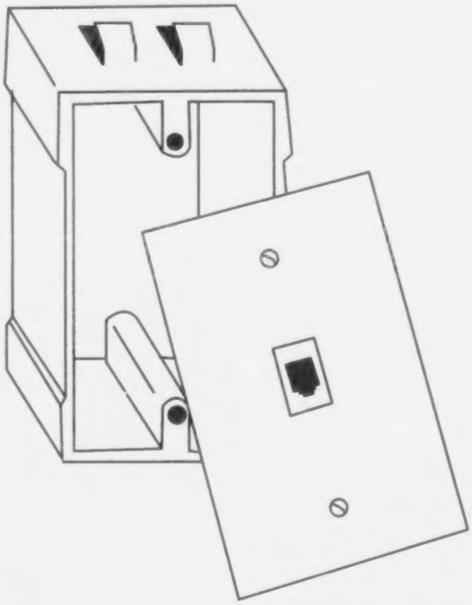
Standard 2 Pair (quad wire) Color Codes		
Pair 1	Tip Ring	Green Red
Pair 2	Tip Ring	Black Yellow

Quad Wire (aka POTS wire)

- Telephone conductor installation requirements
  - — Shall not be placed in conduit or box with electric light and power conductors unless separated by a barrier
  - — Should not share the same stud space as electrical branch circuit wring
  - — Should be kept at least 12 inches from branch circuit wiring where the telephone cables run parallel with telephone conductors to prevent induction noises
  - — Should not share the same bored holes as electrical wiring, plumbing, and gas pipes
  - — Should be kept away from hot water pipes, hot air ducts, and other heat sources that might damage the insulation
  - — Telephone circuits require a separate pair of conductors from the telephone all the way back to the phone company's switching center.

- For new construction installations, standard electrical boxes are used at telephone outlet locations. These boxes will support wall phones or modular plates.

Figure 26



- The two wiring schemes most common in wiring residences are:
  - The Series method (not recommended)–the normal wiring method used before 1980. It's often called daisy chaining and consists of stringing a telephone wire from one jack to the next.
  - The Star method (recommended)–consists of running a phone line from each jack or room to a central point in the house.
- All telephone hook-ups are wired in a parallel pattern.

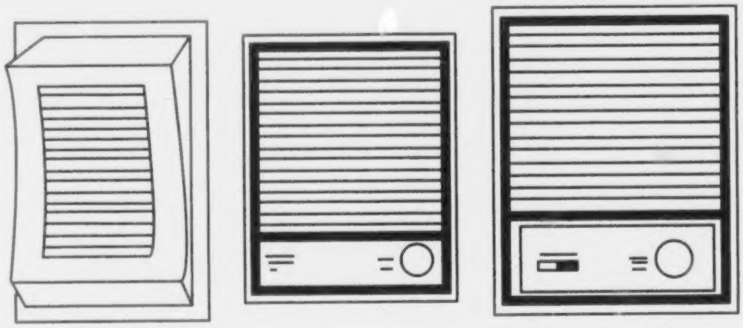
Note: *NEC*, Art. 800 covers installation requirements for phone systems. Local telephone companies may also have additional requirements. There is little danger of electrical shock from the telephone's own voltage when the phone is not ringing (only 48-volt DC is present). The operation of the phone signaling device (ringing) requires 85- to 90-volt AC. This voltage is supplied by the telephone company. If contact is made with this higher AC voltage, it can be uncomfortable but not harmful. To avoid electrical shock, take the receiver off the hook when working on the system.

b. Intercom system

- This low voltage wiring system allows one-way monitoring or two-way conversation communication throughout the residence.
- Most systems today also incorporate radio and tape through the system speakers.
- The system also provides added security with door answering communications without opening your door to a stranger.

  Note: Shown below are typical system components.

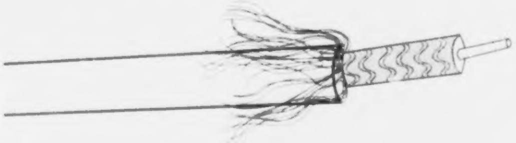
  Figure 27



c. Television antenna

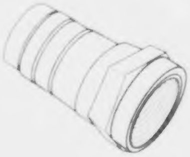
- The television antenna and Community Antenna Television (CATV or Cable) system installed in the home is regulated by Art. 820 of the *NEC*.
- Television cable is available in two basic types: twin lead (300 ohms) and coaxial (75 ohms).
- All television cable systems must be grounded.
- If a separate grounding electrode is used, other than a service grounding electrode, the two electrodes must be bonded.
- Components of a CATV system
  - Coaxial cable (75 ohms)

    Figure 28



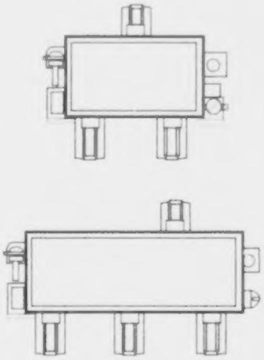
— Terminations

Figure 29



— Splitters

Figure 30



Objective 11

Smoke and fire alarm systems

Note: *NEC* Article 760-C pertains to requirements for fire protection signalling systems.

a. Heat and smoke detectors installed in a residence give people early warning of the presence of fire.

Note: Fire is the third leading cause of accidental fatalities. Home fires account for the biggest share of the deaths; most occur at night when people are asleep. Heat and smoke detectors are available in single or multi-installation types.

b. Two types of fire warning device commonly used in residences are heat detectors and smoke detectors.

c. Heat detectors sense a specific fixed temperature, such as 135°F or 200°F, or a rate-of-rise (12 to 15 degrees per minute), such as rises caused by flash fires.

d. The two most common types of smoke detectors are:

- **Photoelectric**—This detector has a light sensor that measures the amount of light in a chamber. Smoke reduces the amount of light and an alarm is sounded.

  Note: This type of detector is most useful in situations where burning materials, such as rags, mattresses, and furniture create great quantities of smoke.

- **Ionization**—This detector has a source of particles that ionize the air in the chamber. Inside the chamber are two plates of opposite charge. The ionized air conducts a small current (millionths of an ampere) between the plates. Smoke entering this chamber restricts the current flow causing an alarm to sound.

  Note: This type of detector is most useful in situations where burning materials, such as gasoline or alcohol, create very small amounts of smoke.

Objective 12

Operation of a garage door opener

a. The opener contains a motor, gear reduction unit, motor reversing switch, transformer, and electric brake. All of the components are pre-assembled.

b. The electrically operated reversing switch can be controlled by push-button or key operated switch stations and radio operated controllers (remote control).

c. The push-button or key operated station consists of a normally-open momentary contact switch connected by 2-wire, low voltage cable to the control unit. A photoelectric sensor system is also connected to the control unit by low voltage cable to insure a clear path for the door to travel. Actuation of switches causes the step relay to close, energizing the motor in the opposite direction of its previous travel.

d. The radio-controlled operator consists of a transmitter of a set frequency. The receiver on the control unit is set for the corresponding frequency so that when the receiver detects a signal of that frequency (from the remote-control device) it will energize the motor in the opposite direction of its previous travel.

Objective 13

Focus Assignment—List Licensing Requirements for Low Voltage Wiring Systems

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Assignment answers complete	______
• Prepared for class discussion	______

Basic Skills

Reading Writing Employability

Introduction

In this unit you will be learning about a variety of low voltage systems. Individual cities and states have varying requirements for licensing low voltage technicians. There may even be separate requirements for different systems. Example: Licensing requirements for installing security systems may differ from those required for fiber optics.

Directions

Contact the authority having jurisdiction in your city, county, or state for information on licensing requirements for low voltage related trades. List requirements in the space provided and be prepared to discuss your findings in class.

Focus Assignment Sheet

Objective 14

Assignment Sheet 1—List Uses of Low Voltage Cable

Name ______________________ Overall Rating __________

Date ______________________

Evaluation Criteria	Rating
• Uses listed for all types of cables	_____
• All answers correct per answer to Assignment Sheet 1	_____

Basic Skills

Reading Writing

Directions

Refer to *National Electrical Code* Articles 725, 760, and 800 to list the description and uses for the following cables.

1. CL2P ______________________
2. CL2R ______________________
3. CL2 ______________________
4. CL2X ______________________
5. NPLFP ______________________
6. NPLFR ______________________
7. NPLF ______________________
8. FPLP ______________________
9. FPLR ______________________
10. FPL ______________________
11. CMP ______________________
12. CMR ______________________
13. CM ______________________
14. CATVP ______________________
15. CATVR ______________________
16. CATV ______________________

Objective 15

Assignment Sheet 2—Draw a Wiring Diagram Indicating the Proper Connections for a Single Smoke Detector and Interconnecting Smoke Detectors

Name ______________________________ Overall Rating __________

Date ______________________________

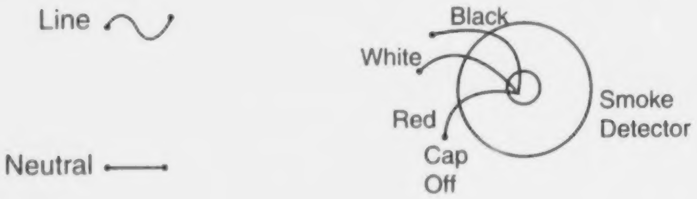
Evaluation Criteria	Rating
• All connections indicated	______
• Correct symbols used	______
• Circuit wiring correct configuration per answer to assignment sheet	______

Basic Skills

Reading Writing

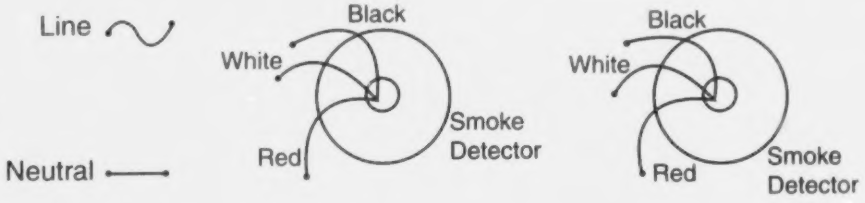
Directions

Draw a wiring diagram indicating the proper connections for a single smoke detector and two interconnecting smoke detectors.


Line
Neutral
Black
White
Red
Cap
Off
Smoke
Detector

Directions

Make connections so that both alarms operate when either test button is pressed.


Line
Neutral
Black
White
Red
Smoke
Detector
Black
White
Red
Smoke
Detector

Objective 16

Job Sheet 1—Wire a Two-Button Chime Circuit

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Two door bell buttons
- 18-3 and 18-2 bell wire cables
- 16-volt transformer
- Chime with front and back call
- 12-2G or 14-2G NM cable
- Electrician's hammer
- Long-nose pliers
- Flat-blade screwdriver
- Cable staples
- 3/8-inch cable clamp
- Stud wall or shop board
- 120-volt power supply
- Pocket knife
- Wire strippers
- Wire connectors
- Octagon box and blank plate with 1/2-inch KO
- 3/4-inch #10 metal tapping screws
- Drill motor and bit or brace
- 1/2-inch or lager wood bit
- Extension cord
- Header board (short piece of 1" x 6" or 2" x 4")
- Four 16-penny nails
- Safety glasses
- GFCI

Job Sheet 1

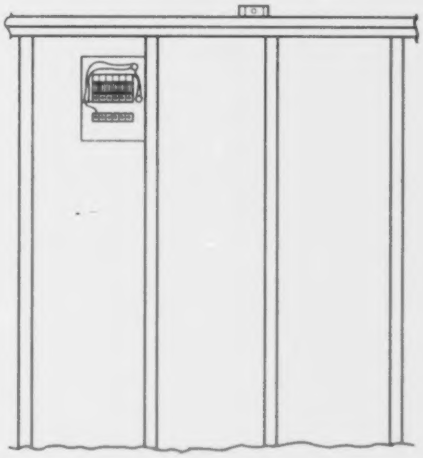
Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount box.

Note: If mounted on a wall plate this box must be above insulation. The best place to mount the transformer is a furnace closet so you can change it without going into the attic.

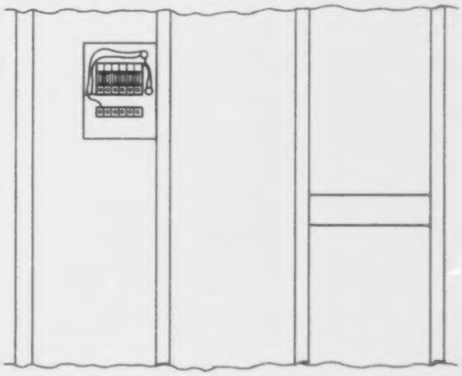
Figure 1



☐ 3. Mount header

Note: It must be mounted flush with wall surface.

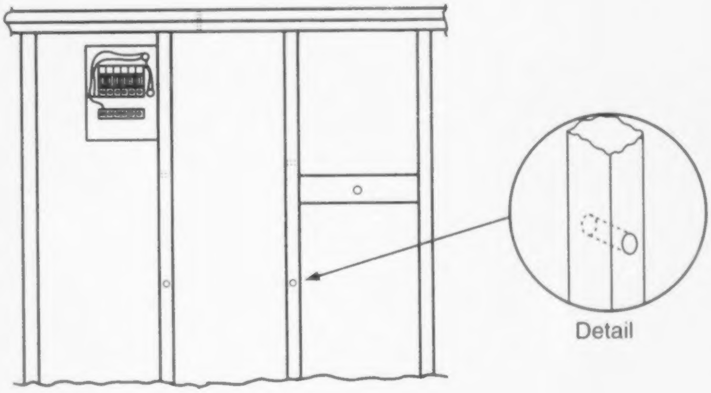
Figure 2



☐ 4. Drill holes.

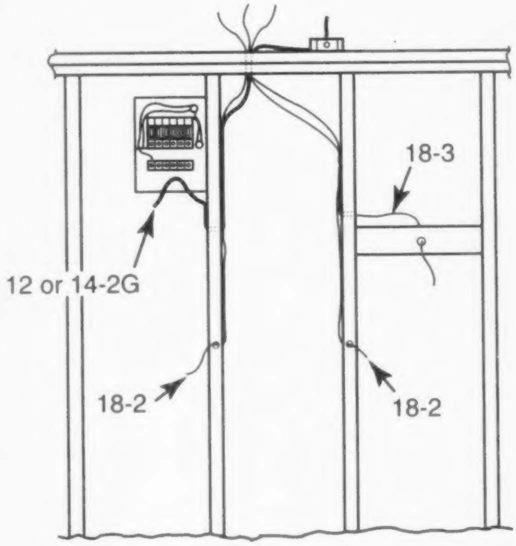
Note: On a residential rough-in, button wires are drilled through at an angle in the door opening. Use GFCI when drilling.

Figure 3



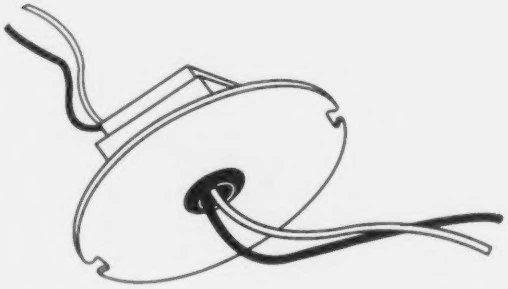
☐ 5. Run cable.

Figure 4


18-3
12 or 14-2G
18-2
18-2

☐ 6. Mount transformer to blank plate.

Figure 5

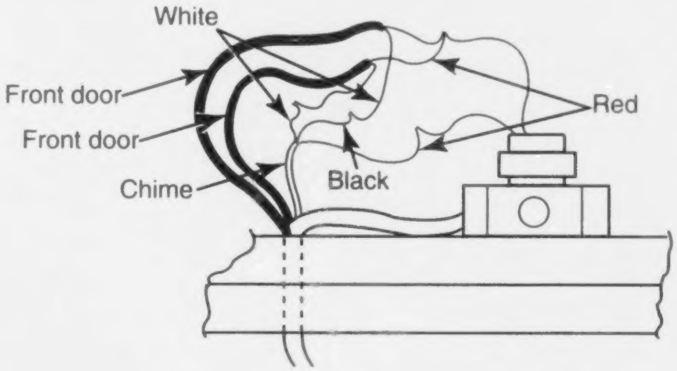


☐ 7. Connect transformer supply leads to cable from panel.

☐ 8. Mount blank plate on octagon box.

☐ 9. Make low voltage connections at transformer.

Figure 6

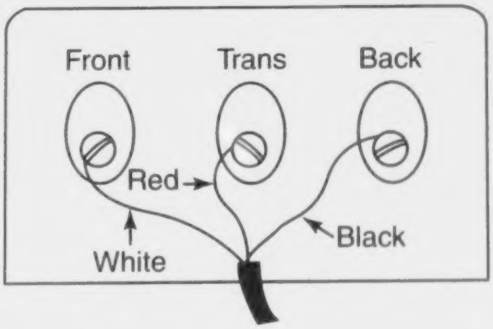

White
Front door
Front door
Chime
Black
Red

☐ 10. Mount chime on header.

Note: Put cable through opening in subbase before securing chime.

☐ 11. Connect conductors to chime.

Figure 7



☐ 12. Connect buttons.

☐ 13. Connect conductors at panel.

☐ 14. Turn on breaker.

☐ 15. Push front button.

Note: A two-tone chime should be heard.

☐ 16. Push back button.

Note: A one-tone chime should be heard.

☐ 17. Have instructor evaluate work.

☐ 18. Turn off breaker.

☐ 19. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Objective 17

Job Sheet 2—Wire Two Interconnecting Telephone Wall Jacks

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	**Rating**
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

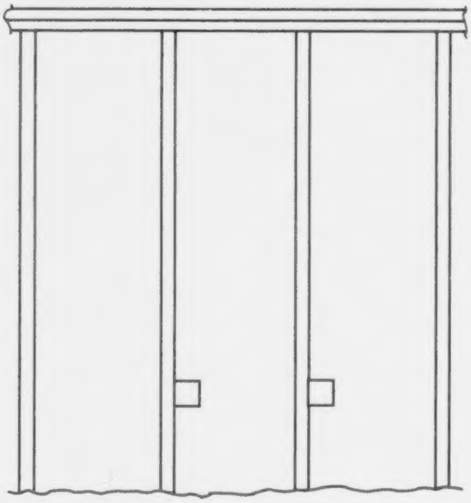
- Two single gang boxes
- Two or four pair telephone cable
- Staples
- Stud wall or shop board
- Nails to secure boxes
- Two telephone wall plates
- Electrician's hammer
- Flat blade screwdriver
- Lineman's pliers
- Long nose pliers
- Wire strippers
- Drill motor
- $1/2$" or larger wood bit
- Extension cord
- Safety glasses
- Portable GFCI

Procedure

☐ 1. Put on safety glasses and gather equipment and materials

☐ 2. Mount boxes 12″ A.F.F.

Figure 1

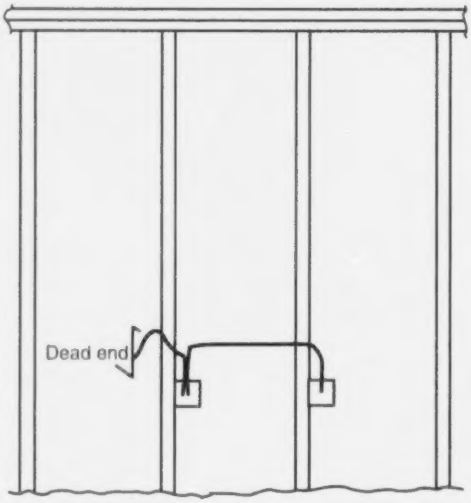


☐ 3. Drill holes for telephone cable.

Note: Use your GFCI when drilling.

☐ 4. Run telephone cable between boxes and leave a piece dead ended out of box #1.

Figure 2



☐ 5. Strip telephone cable using wire strippers.

☐ 6. Connect telephone cable to telephone wall plates by using color code.

☐ 7. Have instructor evaluate this project.

☐ 8. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ____________________

____

____

Objective 17

Job Sheet 3—Wire Two Interconnecting Smoke Detectors

Name ______________________ Attempt Number ________

Date ______________________ Overall Rating ________

Evaluation Criteria	Rating
• Gathered and used appropriate equipment and materials	______
• Performed procedure safely	______
• Performed all steps in procedure	______
• Performed steps in correct sequence	______
• Cleaned work area	______

Basic Skills

Reading Employability

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, equipment, and materials

- Two single-gang plaster rings or two regular device boxes
- 12-3G or 14-3G NM cable
- 12-2G or 14-2NM cable
- Wire connectors
- Staples
- Stud wall or shop board
- Fasteners (nails or screws) to secure boxes and hanger bar
- Two line voltage smoke detectors with or without battery back up
- Electrician's hammer
- Flat-blade screwdriver
- Lineman's pliers
- Long-nose pliers
- Knife
- Wire strippers
- Drill motor and bit or brace
- Extension cord if a drill motor is used
- 1/2-inch or larger wood bit
- Safety glasses
- Portable GFCI
- 120-volt power supply

Note: A breaker panel with one breaker is needed.

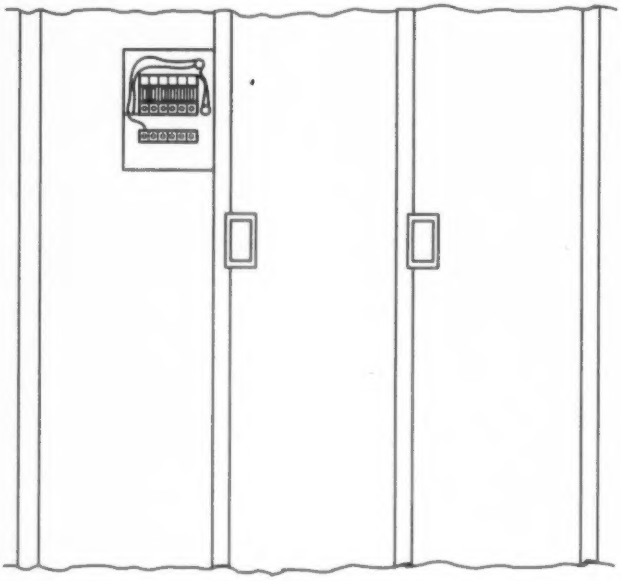
Job Sheet 3

Procedure

☐ 1. Put on safety glasses and gather equipment and materials.

☐ 2. Mount boxes

Figure 1



☐ 3. Drill holes for power cable runs.

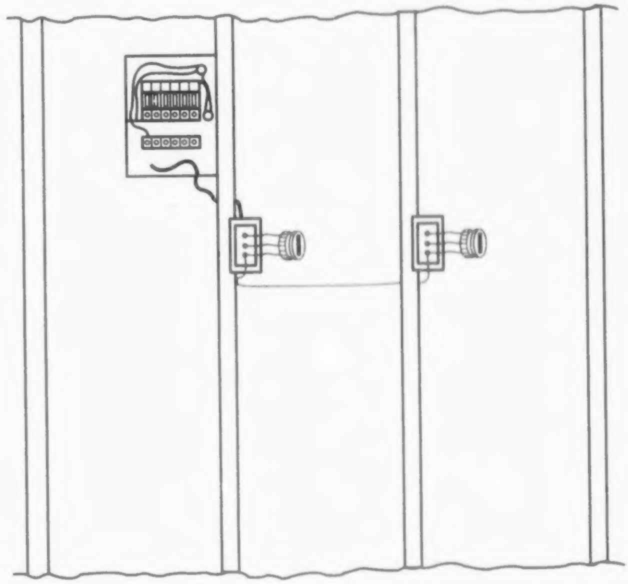
Note: Use your GFCI when drilling.

☐ 4. Run 120-volt supply cable from panel to first outlet box (12-2G or 14-2G NM.)

☐ 5. Run 120-volt cable from first box to second box (12-3G or 14-3G NM.)

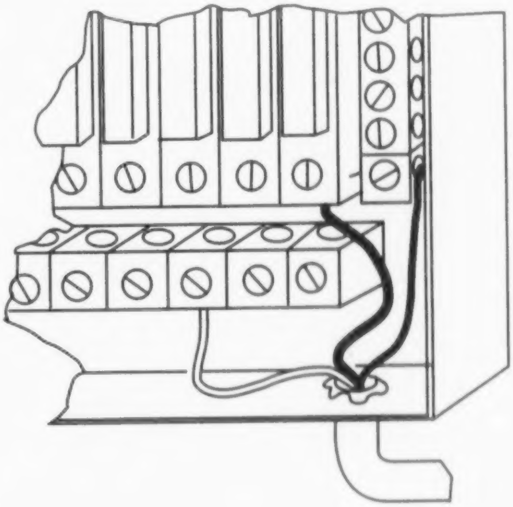
☐ 6. Make connections to smoke detector terminals or pig tails in accordance with manufacturer's instructions (Refer to Assignment Sheet 2.)

Figure 2



☐ 7. Make up panel.

Figure 3



☐ 8. Turn on breaker.

☐ 9. Test that both alarms operate when either test button is pressed.

☐ 10. Have your instructor evaluate this project.

☐ 11. Turn off breaker

☐ 12. Clean work area, and return equipment and materials to proper storage.

Evaluator's Comments: ______________________________

____

____

Unit Contents

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Student Page

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Information Sheet 6–5

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- 1—Home Automation 6–15
- 2—Low Voltage Blueprint Symbols 6–17

Assignment Sheets

- 1—Use Article 780 of the *National Electrical Code* to Answer Questions Related to Home Automation Wiring 6–19

Objective Sheet

Unit Objective

After completing this unit, the student should be able to show how an automated home operates and answer questions related to home automation . The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to home automation with their definitions.
2. Define the term "home automation."
3. Draw diagram showing the operation of an automated home.
4. List six components of a home automation system.
5. Match the types of cable used in home automation with their uses.
6. Select true statements concerning types of controllers.
7. Identify special tools used in home automation.
8. Use Article 780 of the *National Electrical Code* to answer questions related to home automation. (Assignment Sheet 1)

Information Sheet

Objective 1

Terms and definitions

a. **Audio switcher**—Allows audio sources to be mixed and/or matched to audio zones or rooms

b. **Devices**—Can include electric windows, fireplaces, televisions, VCR's, DVD's, CD players, stereos, draperies, pianos, and gates

c. **LAN**—Local area network

d. **Star configuration**—Cabling configuration whereby cables are run from each jack or room to a central point in the house, usually the system controller

e. **Structured cabling**—The low voltage cable installed in a home to handle the data, video, and audio needs of the home

f. **Sub-systems**—Can include lighting, heating and air conditioning, audio/visual, lawn irrigation and security systems

g. **System controller**—Referred to as the "brain" of the system, it manages all home automation system functions

Objective 2

Definition of home automation

A stand alone, computer based home management system that combines today's latest technology with an integrated home network of energy, communication, lighting, audio/visual, security, and peripheral cables. This allows different sub-systems and devices to work together.

Note: See Student Supplement 1 for additional information.

Objective 3

Operation of an automated home

Note: The following steps take place instantaneously once an action has been entered.

a. Individual initiates an action through the controlling device.

b. Controlling device sends request to system controller.

c. System controller sends command to appropriate controllable device.

   Note: System controller may be actuated by preset commands based on an event or time of day, month, or year.

d. Controllable device sends "action completed" message back to system controller.

e. System controller sends "request completed" message back to the controlling device and if a touch panel has been used, it notifies individual that action has been completed.

Note: The home automation system provides two-way communication between the system controller, the various components, and the user controllers.

Figure 1

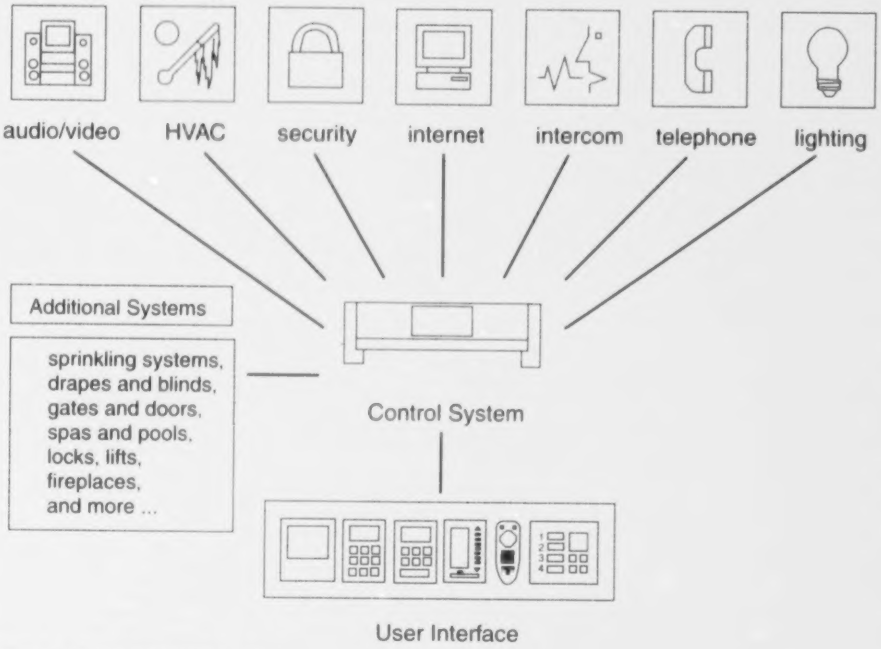

audio/video
HVAC
security
internet
intercom
telephone
lighting
Additional Systems
sprinkling systems,
drapes and blinds,
gates and doors,
spas and pools,
locks, lifts,
fireplaces,
and more ...
Control System
User Interface

Photo courtesy of PHAST by Panja

Objective 4

Components of a home automation system

Note: Listed below are some of the more popular options in home automation, however they do not represent all the options available.

a. Lighting Controls—preset or mood lighting allows for the proper lighting levels depending on the desired activity.

- Local Lighting Control—light switch is replaced by an "intelligent" light switch that does the switching or dimming of the lighting load.

  Note: Light switches can still be operated manually.

Figure 2—Dimming Switch

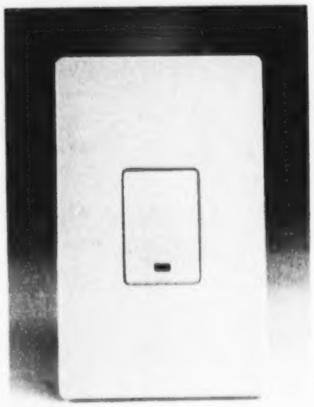


Photo courtesy of PHAST by Panja

- Centralized Lighting Control—A centralized unit, usually located in a closet or mechanical room, containing dimming or switching modules that control the lighting in other rooms.

Figure 3—Central Dimming Panel

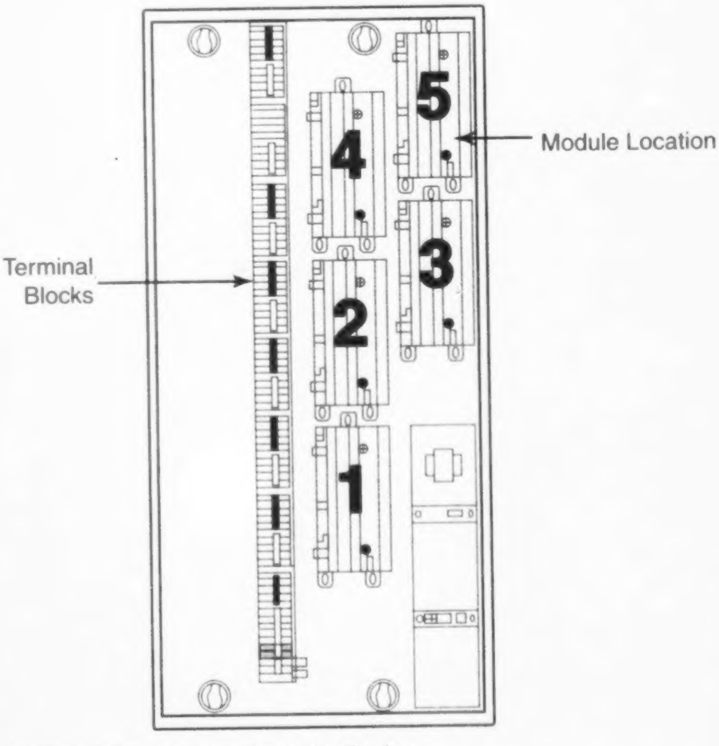


Diagram courtesy of Lutron Electronics Co., Inc.

Figure 4—Connection of a Dimming Module

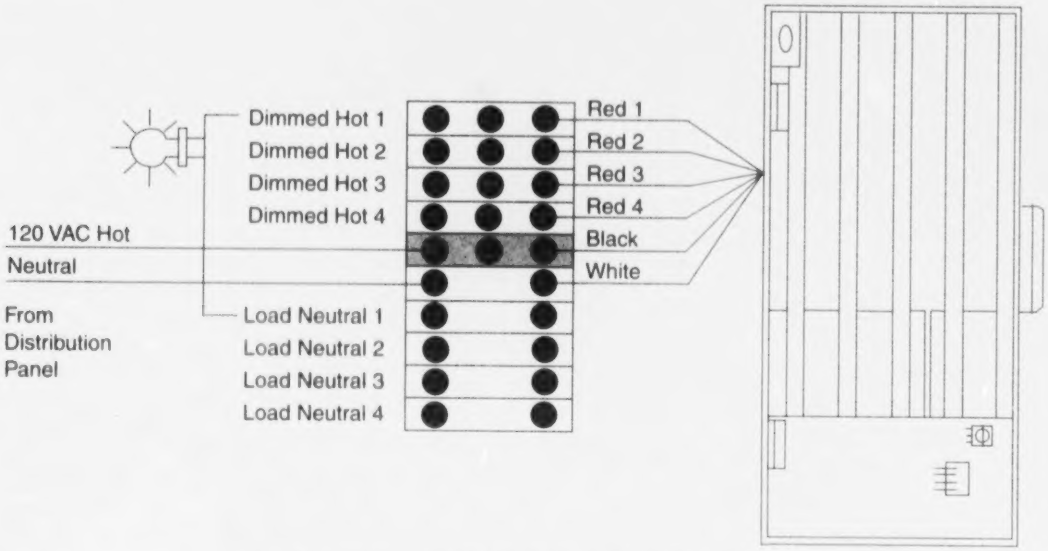

Dimmed Hot 1
Dimmed Hot 2
Dimmed Hot 3
Dimmed Hot 4
120 VAC Hot
Neutral
From Distribution Panel
Load Neutral 1
Load Neutral 2
Load Neutral 3
Load Neutral 4
Red 1
Red 2
Red 3
Red 4
Black
White

Diagram courtesy of Lutron Electronics Co., Inc.

b. Environmental Controls—May include heating and air conditioning, windows and window covers, and attic fans.

- Heating and air conditioning—Controls the environment by making changes to the temperature, or by changing the mode of the thermostat.
- Windows and window covers—Can open or close windows, mini-blinds or other types of window coverings, to let the sun heat the home or to help keep the home cool.
- Attic fans can allow fresh air into the home at pre-programmed times.

c. Multi-Room/Source Audio—A system that distributes different audio sources to different rooms of the home.

- Utilizes a central distribution system made up of audio switchers and amplifiers.
- Can allow a person in one room to listen to music channels from a digital satellite system, a person in a different room to listen to the CD player, and a person in another room to listen to a stereo tuner.
- A single audio source can also be broadcast to each room in the home.

d. Home Electronics—Includes TV's, VCR's, CD players, DVD players, stereos, and digital satellite systems.

- Home automation allows for the use of only one remote control device.

- Electronics can be controlled from any room in the house.

  Note: The remote control device communicates with the home automation system instead of the individual components.

e. Security Systems—Practically a standard item on new homes.

- Must be installed by a licensed dealer.
- The security system should send information to the home automation system, but the home automation system should not control the security system or send it any information.

  Example: The security system can send a signal to the home automation system that no one is home. The home automation system can then raise or lower thermostats, turn off lights or music, and if a break-in is detected, can turn on all the interior lights and start flashing the outside lights.

f. Peripheral Systems—Consists of information gathering systems and accessory devices.

- Information gathering systems—examples include outdoor temperature sensors, ground moisture sensors, freeze sensors, wind sensors, and light sensors.
- Accessory devices—examples include gates, sprinkler systems, fireplaces, garage doors, fans, locks, and motorized lifts.

Objective 5

Types of cables used in home automation

a. Telecommunications Cable—makes it possible to attach four separate phone lines to each outlet

- The recommended wire is Category 5, 4 pair telecommunications cable.
- Telephone cables must be installed in the"Star" configuration.

b. LAN Cable makes it possible to share computer resources such as programs, printers, and modems

- Most common type of cable used is Category 5.
- LAN cables must be installed in the "Star" configuration.

c. Video Cable—makes it possible to connect digital satellite systems, VCR's, DVD's, security cameras and other types of video in/out put.

- The recommended cable is RG6, which has the necessary bandwidth to handle sophisticated video systems.
- Video cables must be installed in the "Star" configuration

d. System Cable—makes it possible for the home automation system to communicate with the different components of the system

- Each system uses different types of cable. Some may use Category 5, others may use 22-gauge two-conductor, still others may use a jacket containing a pair of 18-gauge and a pair of 22-gauge wires.

- Consult with the home automation expert on what type of cable to run, and to what locations it should be run.

e. Peripheral Device Cable—used to connect to other devices or communicate with other systems

- Depending on its use, this cable could be 22-gauge two or four conductor cable.

- Consult with the home automation expert on what type of cable to run, and to what locations it should be run.

f. Fiber Optic Cable—contains a small filament of glass. Light is sent through the glass, and transceivers at either end transform the light to data and vice versa

- Fiber optic technology is changing almost daily.

- It's recommended that a number of sections of conduit be installed in place of the cable.

  — The conduit should be installed in such a way that it is accessible from an attic or crawl space so that if fiber optic products become available, a pathway is in place for the homeowner to take advantage of this technology.

Objective 6

Types of controllers

a. Keypads—wall mounted controllers that allow the homeowner to press a single button or a series of buttons to access different functions of the home automation system.

- Pressing a button could launch a complex set of instructions or just turn on the light.

  Example: When entering the theatre room, a single button press could turn on the projector, lower the screen, turn on the amplifier, turn on the DVD player, and slowly dim the lights to 15%.

- More advanced keypads may have a number of keys that can be used to control multiple devices or situations.

- The most advanced keypads not only have multiple buttons, but also provide feedback to the homeowner in the form of a menu.

  Note: One of the advantages of keypads is that one single gang box can replace a bank of light switches.

Figure 5—Basic Keypad

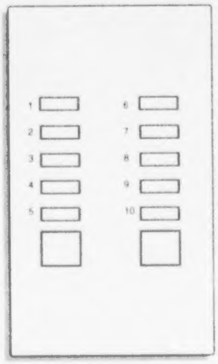


Diagram courtesy of Lutron Electronics Co., Inc.

Figure 6—Advanced Keypad

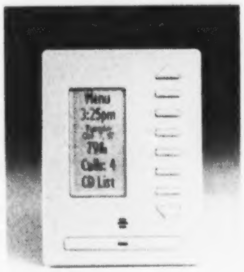


Photo courtesy of PHAST by Panja

b. Remote Controls—Allows the homeowner to use one remote control for all devices being controlled by the home automation system. Available as either infrared or radio frequency.

- Infrared—must be within direct line of sight of the infrared receiver which means that there must be an infrared receiver in every room.
- Radio frequency—more expensive than infrared, but the advantage is that the signal can pass through walls and other obstructions and only one receiver is required.

  Note: The type of construction and the materials in walls can limit the range of the radio frequency controller.

Figure 7—Infrared Remote

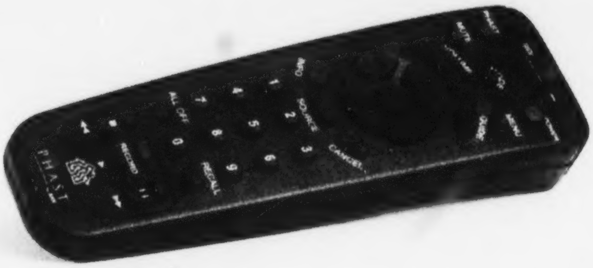


Photo courtesy of PHAST by Panja

c. Touch Panels—A graphic display that looks much like the display of a laptop computer. Displays picture or icons.

- Wireless touch panel
  - Can be infrared and/or radio frequency
- Wired touch panel
  - Connected by cable because the larger display draws more current
  - Can display live video

Figure 8—Wireless and Wired Touch Panels

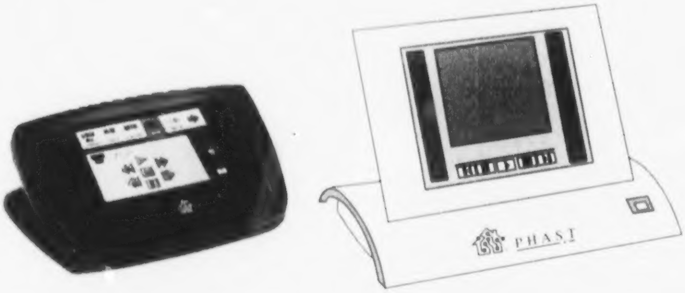


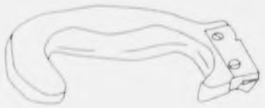
Photo courtesy of PHAST by Panja

Objective 7

Special tools used in home automation wiring

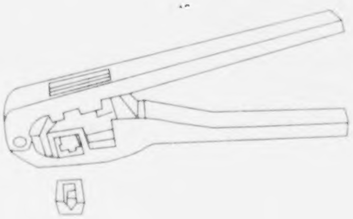
a. Cable slitter—Used to cut the outer protective cover of a hybrid cable without damage to the flat ribbon or the foil shield.

Figure 9



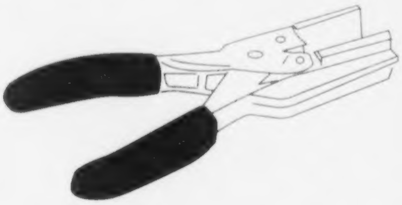
b. Modular crimp tool—Used to install 4-conductor modular plugs on modular line cord

Figure 10



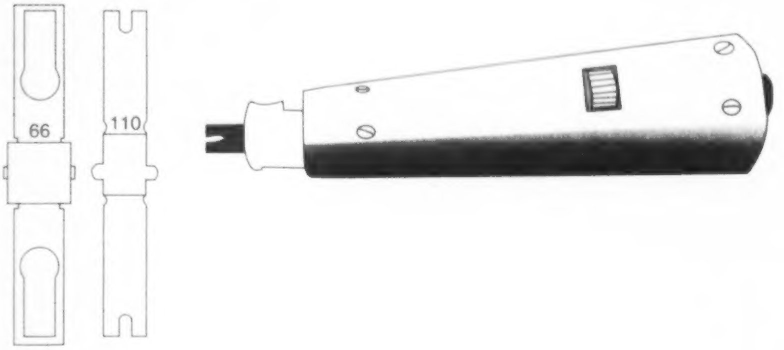
c. Application cable tap tool—Used to terminate application cables with either an applications cable tap or a switch sensor connector

Figure 11



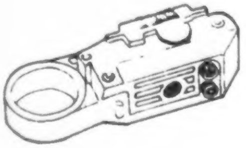
d. Punch down tool—Used to insert telephone conductors into the barrel terminations on a distribution interface board

Figure 12



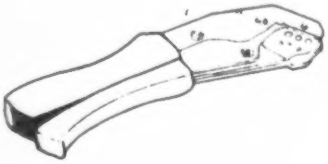
e. Coaxial cable stripper—Used to strip outer covering from the coaxial cable without damage to the copper center conductor

Figure 13



f. Coaxial cable crimper—Used to terminate coaxial cable with either a male or female F-type connector

Figure 14



Student Supplement 1—Home Automation

What is Home Automation?

Home automation is one of the most significant changes to hit the residential construction business in the last 40 years. As with anything new, it is not well understood by the general public. Many builders and electricians are also put off by it, because they do not know what it is, or how it will affect their business.

Home automation can be thought of as an electronic butler. The system can carry out complex routines when told to do so, when a particular event occurs, or when programmed based on the time of day, month, or year. This is possible because the system can be in control of all of the sub-systems and devices. This is not to say that the home automation system alone has control and will not allow a homeowner to control the systems and devices. An automated light switch is still a light switch. A homeowner can still walk over to an automated compact disc player and press "play". However, when these devices are automated, the lights can turn on to 50% and the system can start to play the homeowner's favorite compact disc when he/she arrives home.

Home automation accomplishes this by adding an "intelligent layer" to the home. This layer allows the homeowner to use one easy-to-use system. This system then controls the more wide spread and complex sub-systems.

Why Automate a Home?

The reasons for automation fall into three categories. By far, the most significant reason is convenience. As with microwave ovens, dishwashers, and garage door openers, home automation makes our lives easier. For example, the owner of an automated home is going to have a dinner party. With the push on one button, the exterior lighting is set to a preset level which accents the home and lights a pathway to the front door; the interior lights come on in common rooms, and turns off in unused rooms; a predefined selection of music, at the proper volume, is broadcast throughout the home, and the lawn sprinkler system is disabled so arriving guests don't get wet.

A second reason for home automation is safety. This can be as simple as turning on interior lights when arriving home at night or stairway lights when motion is detected. A more complex example might be when the security system detects a fire, all interior lights come on to help people get out safely, the exterior lights start flashing so the fire department can quickly find the home, and the heating and air conditioning systems are shut down so smoke and fumes are not spread throughout the home.

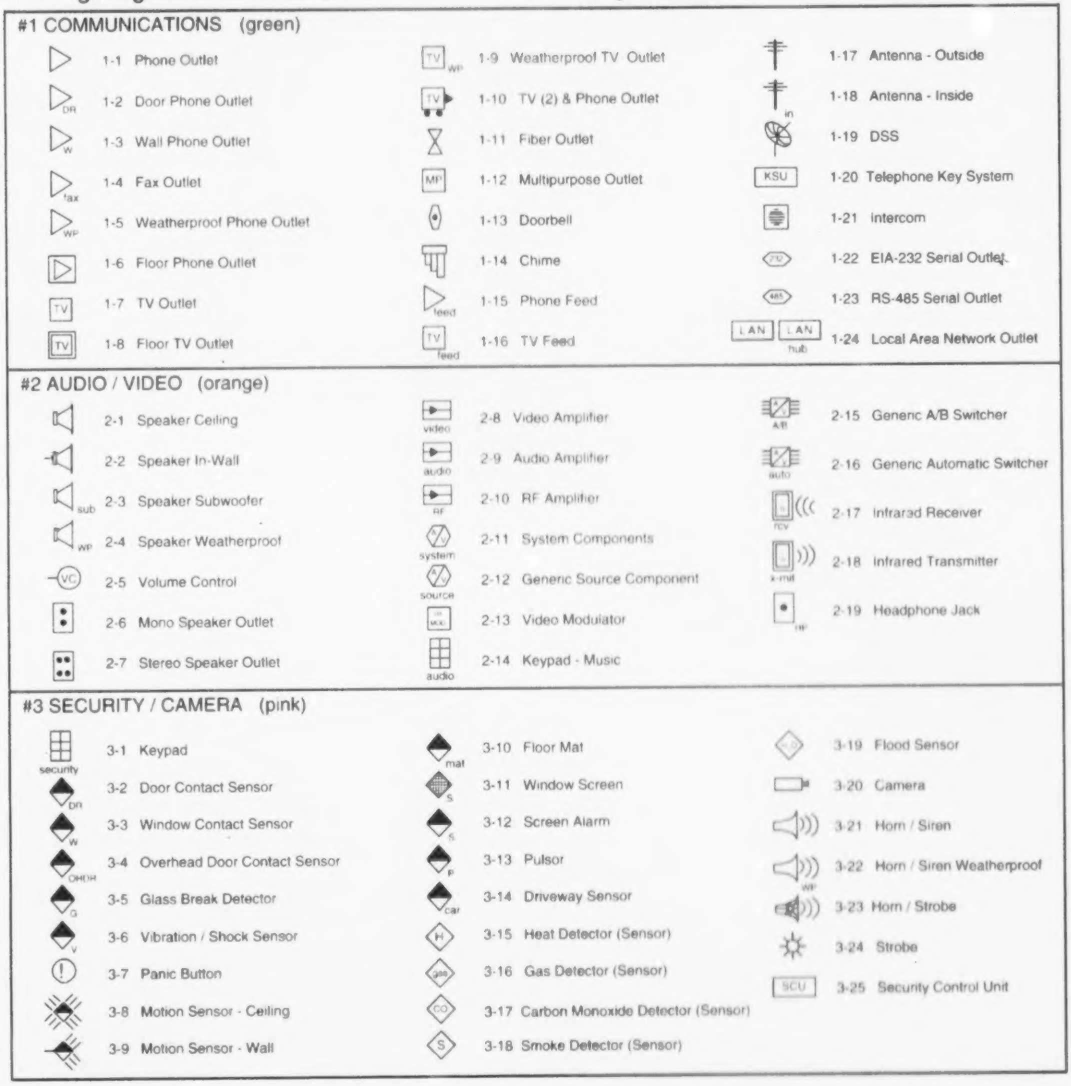
The third reason for home automation is money savings. Although a home automation system cannot be cost justified, there are some things that can be done by the system that helps the homeowner save money. For example, on the way out the door, the press of one button can turn off all interior lights and set the thermostat to a lower temperature in the winter or a higher temperature in the summer.

These are just a few examples of what can be done with home automation. The possibilities are virtually endless. Almost any thing or any situation can be automated to complement a homeowner's lifestyle.

Student Supplement 2—Low Voltage Blueprint Symbols

The icons listed below are examples of blueprint symbols used in low voltage wiring applications. The *icon set* is courtesy of the *Custom Electronic Design and Installation Association* (CEDIA). The intent is for these icons to be located on blueprints and any other documents that identify low voltage wiring and fixture locations. This icon set is quickly receiving universal acceptance as the industry standard. The following catergories have been established with their corresponding colors.

1. Communications—Green
2. Audio/Video—Orange
3. Security/Camera—Pink
4. Lighting/Electrical—Yellow
5. HVAC Environment—Blue
6. Automated Devices—Purple
7. Control—White
8. Surge—Red



#1 COMMUNICATIONS (green)

1-1 Phone Outlet
1-2 Door Phone Outlet
1-3 Wall Phone Outlet
1-4 Fax Outlet
1-5 Weatherproof Phone Outlet
1-6 Floor Phone Outlet
1-7 TV Outlet
1-8 Floor TV Outlet
1-9 Weatherproof TV Outlet
1-10 TV (2) & Phone Outlet
1-11 Fiber Outlet
1-12 Multipurpose Outlet
1-13 Doorbell
1-14 Chime
1-15 Phone Feed
1-16 TV Feed
1-17 Antenna - Outside
1-18 Antenna - Inside
1-19 DSS
1-20 Telephone Key System
1-21 Intercom
1-22 EIA-232 Serial Outlet
1-23 RS-485 Serial Outlet
1-24 Local Area Network Outlet

#2 AUDIO / VIDEO (orange)

2-1 Speaker Ceiling
2-2 Speaker In-Wall
2-3 Speaker Subwoofer
2-4 Speaker Weatherproof
2-5 Volume Control
2-6 Mono Speaker Outlet
2-7 Stereo Speaker Outlet
2-8 Video Amplifier
2-9 Audio Amplifier
2-10 RF Amplifier
2-11 System Components
2-12 Generic Source Component
2-13 Video Modulator
2-14 Keypad - Music
2-15 Generic A/B Switcher
2-16 Generic Automatic Switcher
2-17 Infrared Receiver
2-18 Infrared Transmitter
2-19 Headphone Jack

#3 SECURITY / CAMERA (pink)

3-1 Keypad
3-2 Door Contact Sensor
3-3 Window Contact Sensor
3-4 Overhead Door Contact Sensor
3-5 Glass Break Detector
3-6 Vibration / Shock Sensor
3-7 Panic Button
3-8 Motion Sensor - Ceiling
3-9 Motion Sensor - Wall
3-10 Floor Mat
3-11 Window Screen
3-12 Screen Alarm
3-13 Pulsor
3-14 Driveway Sensor
3-15 Heat Detector (Sensor)
3-16 Gas Detector (Sensor)
3-17 Carbon Monoxide Detector (Sensor)
3-18 Smoke Detector (Sensor)
3-19 Flood Sensor
3-20 Camera
3-21 Horn / Siren
3-22 Horn / Siren Weatherproof
3-23 Horn / Strobe
3-24 Strobe
3-25 Security Control Unit

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Student Supplement 2

#4 LIGHTING / ELECTRICAL (yellow)

⊞ lighting	4-1	Control Keypad
⊖	4-2	Duplex Receptacle Outlet (Both Switched)
⊖	4-3	Controlled Duplex Receptacle Outlet (Half Switched)
⊖	4-4	Floor Controlled Duplex Receptacle Outlet (Both Switched)
⊖	4-5	Floor Controlled Single Receptacle Outlet (Half Switched)
S	4-6	Controlled Switch
S_{dim}	4-7	Controlled Dimmer Switch
S_3	4-8	Controlled 3-Way Switch
S_4	4-9	Controlled 4-Way Switch
S_{3dim}	4-10	Controlled Dimmer 3-Way Switch
S_C	4-11	Controlled Companion Switch
S_M	4-12	Motion Controlled Switch
S B	4-13	Powerline Signal Bridge
	4-14	Powerline Coupler Repeater

#5 HVAC / ENVIRONMENT (blue)

T	5-1	Thermostat
T_R	5-2	Remote Temperature Sensor
T_{out}	5-3	Outside Temperature Sensor
H_2O	5-4	Moisture Sensor
SS	5-5	Snow Sensor
W	5-6	Weather Sensor
EMC	5-7	Energy Management Controller
T_{spa}	5-8	Spa Temperature Sensor
T_{pool}	5-9	Pool Temperature Sensor

#6 AUTOMATED DEVICES (purple)

DOOR	6-1	Electric Door Opener
$DOOR_R$	6-2	Door Lock Release
OH-DOOR	6-3	Overhead Door Opener
LOCK	6-4	Electric Door Lock
DRAPE	6-5	Window Treatment Control (Drape)
SHADE	6-6	Window Treatment Control (Shade)
SPA	6-7	Spa Control
POOL	6-8	Pool Control
SHOWER	6-9	Shower Control
BATH	6-10	Bath Control
FOUNTAIN	6-11	Fountain Control
GATE	6-12	Gate Control
PLANT	6-13	Plant Watering Control
LAWN	6-14	Lawn Sprinkler Control
MELT	6-15	Snow Melt Control
HOT H_2O	6-16	Hot Water Heater
FAN	6-17	Fan
⊠ ⊠	6-18	Motorized Lift / Drop
GAS	6-19	Natural Gas Control
H_2O VALVE	6-20	Water Valve Control
PUMP	6-21	Sump Pump

#7 CONTROL (white)

⊞ keypad	7-1	Keypad
	7-2	Touch Screen
IHC	7-3	Integrated Home Controller
	7-4	Status Indicator
voice control	7-5	Voice Control

#8 SURGE (red)

	8-1	Whole House Electrical Surge Suppression
	8-2	Telephone Surge Suppression
	8-3	Coaxial Surge Suppression
	8-4	Electrical Surge Suppression
UPS	8-5	Uninterrupted Power Supply

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Objective 8

Assignment Sheet 1—Use Article 780 of the *National Electrical Code* to Answer Questions Related to Home Automation

Name ____________________ Overall Rating __________

Date ____________________

Evaluation Criteria	**Rating**
• Article 780 of the *NEC* used to answer questions	______
• Accurate and thorough answers	______
• Neat, legible handwriting	______

Basic Skills

Reading Writing

Directions

Using Article 780 of the *NEC*, answer the following questions related to Home Automation wiring.

1. Under what three conditions should outlets be de-energized?

2. If a controller malfunctions, can all the associated outlets remain energized?

3. What is the maximum current draw permitted by a signaling circuit?

4. Is Home Automation wiring exempt from other articles of the *NEC*?

5. Can a receptacle used on a closed-loop power distribution system be interchanged with other receptacles?